PROCEEDINGS

OF THE

TWELFTH ANNUAL CONVENTION

OF THE

American Railway Engineering and Maintenance of Way Association

HELD AT THE

CONGRESS HOTEL, CHICAGO, ILLINOIS

March 21, 22 and 23, 1911

VOLUME 12
PART 1

PUBLISHED UNDER DIRECTION OF THE COMMITTEE
ON PUBLICATIONS
1911

TABLE OF CONTENTS.

BUSINESS SESSION.

PAGE.

President's Address 12-15
Report of Secretary 16-19
Report of Treasurer 19, 20
Reports of Standing and Special Committees 20-25
Election of Officers 25, 26
New Business 26-38
Revision of Constitution 38

CONSTITUTION.

CONSTITUTION 43-51

- Name, Object and Location 43
- Membership 43, 44
- Admissions and Expulsions 44, 45
- Dues 46
- Officers 46, 47
- Nomination and Election of Officers 47-49
- Management 49, 50
- Meetings 50, 51
- Amendments 51

GENERAL INFORMATION.

GENERAL INFORMATION 52-55

- Appointment of Committees and Outline of Work 52
- Preparation of Committee Reports 52-54
- Publication of Committee Reports 54
- Consideration of Committee Reports 55
- General Rules for the Publication of the Manual 56

COMMITTEE REPORTS AND DISCUSSIONS.

PAGE.

RULES AND ORGANIZATION 59-90
- Introductory 59, 60
- Conclusions 60, 61
- Compilation of Rules of Railway Companies, with Suggestions for New Rules 63-90
- Discussion 91-96

SIGNALS AND INTERLOCKING 97-129
- Introductory 97-100
- Revised Specifications for Mineral Matter Rubber Compound Insulated Signal Wire for Current of 660 Volts or Less 101-104
- Specifications for Mineral Matter Rubber Compound Insulated Aerial Braided Cables for Current of 660 Volts or Less 105-109
- Mineral Matter Rubber Compound, Insulated, Lead-Covered, Armored Submarine Cable for 660 or Lower Voltage Service 110-114
- Double-Braided, Weatherproof, Hard-Drawn, Copper Line Wire 115, 116
- Double-Braided, Weatherproof, Galvanized "B" Iron Line Wire 117-119
- Double-Braided, Weatherproof, Hard-Drawn, Copper-Clad, Steel Line Wire 120-122
- Specifications for Galvanized E.B.B. Iron Bond Wires 123-125
- Stranded and Flexible Conductors 125, 126
- Wire Inspection Report Blank 127
- Discussion 131-134

ELECTRICITY 135-220
- Introductory 135-139
- Bibliography 140-151
- Clearances 152-155
- Transmission Line Crossings 155
- Maintenance Organization 155-163, 199
- Relation to Track Structures 163, 164
- Conclusions 164, 165
- Diagrams Showing Clearances on American Railways 166-198
- Transmission Line Crossings 200-220
- Discussion 221-230

PAGE.

BRINE DRIPPINGS FROM REFRIGERATOR CARS........231, 232

Introductory 231, 232
Conclusions 232
Discussion 233, 234

YARDS AND TERMINALS..............................235-262

Introductory 235
Revision of Manual...............................235, 236
Mechanical Handling of Freight...................236, 237
Design of Passenger Terminals of Medium Size.....237-240
Conclusions 240
Freight Yards for Interchange Traffic............... 241
Mechanical Handling of Freight...................243-249
Arrangement for Loading Tracks at Piers..........250-253
Facilities and Traffic at Passenger Terminals....254, 255
Improvements for the Handling of Interchange Freight Business at Chicago...256, 257
Notes on New Passenger Terminals.................258-260
Bibliography on Stations, Yards and Terminals....261, 262
Discussion 263-273

WOODEN BRIDGES AND TRESTLES.......................275-306

Introductory 275, 276
Conclusions 276, 277
Pile Record Form.................................... 278
Pile Driving—Principles of Practice..............279, 280
Overdriving 281-286
Pile Drivers.....................................286-298
Sheet Piles......................................298-302
Strength of Sheet Piling.........................303, 304
Mechanical Protection of Piles Against Marine Wood Borers..305, 306
Discussion 307-326

ECONOMICS OF RAILWAY LOCATION....................327-335

Introductory 327-329
Balanced Grades for Use of Assistant Engines.....330-335
Discussion 336-338

PAGE.

BALLAST 339-346

Introductory 339, 340
Revision of Manual.. 340
Proper Thickness of Ballast...............................341-343
Conclusion 343
Depth of Ballast Used by Various Railways.................345, 346
Discussion 347-355

TIES 357-397

Introductory 357, 358
Statistics of Cross-Ties..................................359-370
Metal and Composite Ties..................................371-389
Use of Cypress as Tie Timber..............................390-394
Abrasion of Cross-Ties by Track Rails.....................395-397
Discussion 398-400

TRACK 401-446

Introductory 401, 402
Revision of Manual.. 402
General Instructions for Ordering or Contracting for Frogs,
Crossings and Switches................................403-409
Manganese in Frogs, Crossings and Switch Points............ 410
Track Fastenings with Treated Ties........................410, 415
Conclusions 415
Spirals 417-438
Derivation of Formulas....................................420-424
Formulas for Field Use....................................424, 425
Fundamental Formulas 420
Maintenance of Line and Alinement......................... 427
Minimum Length of Easement Curve.......................... 428
Notation 418-420
Staking Spirals by Deflections............................ 426
Staking Spirals by Offsets................................ 427
Table of Functions of the Ten-Chord Spiral................ 429
Selection of Length of Transition Spiral..................439-446
Discussion 447-465

PAGE.

RAIL (See Vol. 12, Part 2, for Report) 467

Discussion 467-475

MASONRY 477-578

Introductory 477, 478
Revision of Manual 478-480
Waterproofing of Masonry 480-514
Monolithic Construction 514-517
Reinforced Concrete Trestles 517-529
Protecting and Waterproofing Solid Floor Bridges 530-541
Methods Used 530-535
Results of Examinations 535, 536
General Information and Comments 536-539
Conclusions 540, 541
Specifications and Instructions for Waterproofing Metal and Masonry Structures, Pennsylvania Lines, Southwest System 542, 543
Bibliography of Waterproofing 564-578
Discussion 579-586

BUILDINGS 587-622

Introductory 587, 588
Roof Coverings 588-612
Bituminous Roofing Materials 589-592
Built-up Roofs 596
Conclusions 610-612
Concrete Roofings 608, 609
Cost 600
Felts 595, 596
Fire Protection 610
Inspection 597-599
Iron or Steel Roofings 607, 608
Methods of Application 609, 610
Miscellaneous Metals 608
Prepared or Ready Roofings 601-605
Slate 606
Specifications 597-601

BUILDINGS—CONTINUED. PAGE.

Tars 592-595
Tests on 617-622
Tile 606, 607
Wood Shingles ....6$5, 606
Objects of Tests and Investigations at Underwriters' Laboratories 613-616
Tests on Roof Coverings..617-622
Discussion 623-625

BUSINESS SESSION

PROCEEDINGS.

The object of this Association is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways. Its action is not binding upon its members.

TUESDAY, MARCH 21, 1911.

MORNING SESSION.

The convention was called to order by the President, Mr. L. C. Fritch, Chief Engineer, Chicago Great Western Railroad, at 9 a. m.

The President:—Gentlemen, please come to order. We welcome you to the Twelfth Annual Convention of the American Railway Engineering and Maintenance of Way Association, and the meeting is now declared open for the transaction of such business as may come before it.

It seems proper that the Divine Blessing of Providence be invoked upon our work, and the Rev. Dr. Joseph A. Vance, Pastor of the Hyde Park Presbyterian Church of Chicago, will lead us in prayer.

(Rev. Dr. Vance asked the Divine Blessing.)

The President:—The first business before us is the reading of the Minutes of the last annual convention, but inasmuch as these Minutes are quite voluminous and a copy has been furnished to each member, the reading will be dispensed with and the Minutes will be considered approved, unless there is objection. There being no objection, the Minutes stand approved as printed.

The privileges of the floor are extended to any railway officials present, who are not members of the Association, and to professors of colleges and universities, and they are cordially invited to take part in the discussions.

The Chair would suggest that each gentleman, on rising to speak for the first time, will give his name and the name of the railway with which he is connected, in order that the reporters may get it correctly. We have a very long program before us, and it is essential that every member speak promptly and to the point.

The next order of business is the address of the President.

PRESIDENT'S ADDRESS.

To the Members of the American Railway Engineering and Maintenance of Way Association:

The progress made by the Association during the year just passed has been gratifying, and the thanks of the Association are due its Committees for their efficient and painstaking labors and the splendid results secured. That interest and enthusiasm in the work has been sustained, is attested by the fact that all of the twenty-two Standing and Special Committees have presented valuable and comprehensive reports for consideration at this convention.

It is noteworthy that in the midst of the busy lives of the members time is found to accomplish so large an amount of work, and to perform it in the efficient and thorough manner in which it is presented. This feature is all the more praiseworthy when it is considered that this organization is a voluntary one, and the time devoted by the members to committee-work is frequently given at a great personal sacrifice and at the expense of much-needed rest.

Prior to the formation of the Association few railways pursued the same methods, or used similar appliances or devices in so far as railway engineering and maintenance of way work was concerned, even under similar climatic, physical and commercial conditions, and there was little, if any, approach to uniformity as to methods and practices. A fertile field seemed therefore to exist, in which it was believed much good might be accomplished by formulating principles of practice and disseminating knowledge pertaining to maintenance of way work.

This Association was formed for the "advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways," and to attain those ends it was deemed essential to investigate matters pertaining to the objects of the Association through Standing and Special Committees; to hold meetings for the discussion of papers and reports; the publication of its conclusions, and the maintenance of a library.

The founders of the Association wisely concluded that the best results would be obtained through Committees, the members of which should be selected with due consideration of their qualifications to deal with particular subjects.

The work of the Association was laid out on unique lines. The entire field of railway engineering and maintenance of way work was originally divided into sixteen divisions, and a Committee appointed to deal with each subject, until now we have nineteen Standing Committees and additional Special Committees to consider matters not coming within the province of the regular Committees.

Each Committee is given a particular phase of the general subject, and they are expected to collect all available information on the subject in hand, to carefully digest the data obtained, to draw therefrom such conclusions as the information seems to warrant and to submit to the

Association its recommendations thereon. Committee reports are to be formulated on the following general plan: An historical review of the subject under discussion, with an outline of its origin and development; an analysis of the most important elements of the subject-matter; an argument, showing the disadvantages of the old and the advantages of the recommended practice; and finally the conclusions of the Committee, giving in concise language and in logical sequence its conclusions and recommendations. That these methods have been productive of excellent results is abundantly shown in our Proceedings for the last decade.

However, the formulation of principles of practice is not the only or main function of our Association. The collection and dissemination of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways is quite as important, and it will be conceded that along these lines the Association has made an enviable record. Since the formation of the Association there have been issued over twenty thousand pages of printed matter—all of it live and useful material pertaining to our profession.

While it may be true that not all of our recommendations have met with universal approval, nevertheless they have served as a guide to the Engineer in arriving at a solution of his problems. It would be practically impossible to formulate principles of practice applicable to all sections of the country, with its diversity of conditions of soil, climate and commercial requirements.

Some of our critics have said, "Your Association is gathering a large amount of information, but your conclusions are not always sound. Your Committee reports need boiling down; the wheat needs winnowing from the chaff."

My own opinion is that there is no foundation for these criticisms, which is evidenced by the fact that our Proceedings are used as works of reference by the ablest Engineers, not only of this country, but of the world.

There is a Roman adage that says, "Whatever you do, do it well, and always consider the consequences of what you do." This is wise counsel, and in my judgment it applies to our own work. We should be careful not to spend too much time and effort on details and peculiar methods, and neglect underlying principles upon which all good practice is founded. We should aim at principles that may be universally applied. For example, good sound specifications covering the materials of Engineering, which are susceptible of universal application, are of more use than methods or particular plans or designs, which have only limited application. The work of our Association that will stand out prominently is that which is of the greatest use to the greatest number.

Perhaps too much stress is laid upon the establishment of standards. In a progressive art, such as ours, there should be no such word as "standard." What is standard to-day may be obsolete to-morrow. Improvement and advancement is the order of the day, and in no profession is this truer than in our own.

The progress of railway engineering during the past year is perhaps best exemplified in the opening for service of the New York Terminals of the Pennsylvania Railroad, including the tunnels under the Hudson and East Rivers. This great achievement, made possible only by the ability, foresight and courage of that splendid type of man and Engineer, Alexander J. Cassatt, is a fitting and lasting tribute to his genius and memory. It marks an epoch in railway progress, being the first large trunk line railway terminal, complete in its operation with the use of electric traction. This installation awakens us to the sense of a new responsibility that is placed upon us as Engineers, and that is that we should prepare ourselves for the new problems that it will be our duty to solve. It will devolve upon the Engineers of our railways to determine to what extent this new power is justifiable in heavy trunk line service. The question of electrification of trunk lines, and its application to terminals in large cities, has assumed the proportions of a public question in the cities of Boston, Philadelphia, Baltimore, Washington, St. Louis, Chicago; and its extension in New York City to all classes of service is being considered.

It is a problem of great magnitude and involves not only technical skill, but judgment of the highest order, and its solution must, in the final analysis, be made by railway men, familiar with the intricacies of railway operation and its needs. My advice, therefore, would be that railway Engineers prepare for this economic change that has already begun, in order that the problems that demand solution may be solved on a sound basis, and that costly mistakes which ignorance would otherwise impose may be avoided.

We will miss some familiar faces at this convention—men who have aided us in placing this Association on its high plane of usefulness. Among those who have gone to that "other country from whose bourne no traveler ever returns" are Octave Chanute and Samuel M. Rowe, both pioneers in the art of wood preservation; E. P. Dawley, an efficient member of the Committee on Electricity; John F. Hinckley, a valued member of the Rail Committee; Ira G. Rawn, an able member of our first Committee on Yards and Terminals; J. E. Schwitzer, late Chief Engineer of the Canadian Pacific, a valued member of the Committee on Economics of Railway Location; H. L. Laughlin, an efficient member of the Committee on Track.

A notable achievement made during the past year, through the co-operation of the Master Car Builders' Association and our Association, is the final solution of the question of the disposal of brine drippings from refrigerator cars, which has been the bane of railways for nearly thirty years. The conclusion reached provides for retaining the brine drippings in tanks between icing stations and draining them at given points, where facilities are provided for that purpose. This will result in preventing injury to maintenance of way structures and equipment costing the railways in the past thousands of dollars.

There are two important matters coming before this convention for final vote. The name of the Association, which has been unfortunately cumbersome in its length, is to be changed to a shorter one—a desirable innovation.

The proposed change in the Constitution, which will grant to the membership at large a voice in the selection of officers of the Association, is one that will meet with universal approval.

The railway industry is being circumscribed by governmental regulations to the extent that its operations, to the minutest details, are being regulated by law or prescribed by rules of commissions created under Federal or State authority. Some of these regulations are wise and beneficial, and were necessary to purge the railway business of its past sins of omission and commission. However, many of the regulations, conceived by irresponsible persons and for sinister purposes, are a positive menace to the public they were designed to benefit; these will serve no good purpose, but prove a positive check to railway development. In this feature we are vitally interested, and it devolves upon us as citizens, true to our calling, to educate the public to a realization of the rights and the justice that is due the railway industry.

It has been asserted that railways are extravagant and wasteful in their methods of operation and lack system in conducting their business. These charges are not in accordance with the facts as we know them. Organizations similar to our own are giving their best thought to the improvement of methods and to the promotion of efficiency in all departments of railways.

We have an abiding faith in the fairness and common-sense of the American people, and are confident that our incomparable country will progress with undiminished momentum. New lines of railways will continue to be built, existing lines will be revised and rebuilt—and herein lies our duty.

The charter of our existence provides that we shall devote ourselves to the "advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways." We maintain that our Association has justified itself, and that in the future as in the past we will endeavor to do our work honorably, thoroughly and conscientiously, irrespective of regulations, as is the wont of every member of the American Railway Engineering and Maintenance of Way Association.

In closing the term of office as President, I wish to thank the Board of Direction for its hearty co-operation, the Secretary for his untiring devotion to duty, and the Committees for the splendid work which they have accomplished. (Applause.)

The President:—The next order of business will be the reports of the Secretary and of the Treasurer.

Secretary E. H. Fritch presented the following reports:

REPORT OF THE SECRETARY.

To the Members of the American Railway Engineering and Maintenance of Way Association:

I have the honor to present the following report for the year ending March 15, 1911:

MEMBERSHIP.

Total membership at last annual convention		869
Withdrawals during the year	11	
Deceased members	7	
Dropped for non-payment of dues	20	
	—	38
		831
Additions during the year		136
Total membership, March 15, 1911		967
Consisting of:		
Active members		908
Honorary members		3
Associate members		56
		967

GEOGRAPHICAL DISTRIBUTION.

The geographical distribution of the membership is indicated in the following table:

United States	838	Panama	2
Dominion of Canada	76	Australia	1
Mexico	14	Brazil	1
Japan	7	Germany	1
Cuba	6	Great Britain	1
China	5	Guatemala	1
New Zealand	4	Peru	1
Philippine Islands	4	Russia	1
India	2		
Korea	2	Total	967

CLASSIFICATION OF MEMBERS.

The positions held by the members are indicated in the following table:

Presidents	16	Asst. Chief Engrs. Maint. Way	1
Assistant to President	3	Engineers of Construction	12
Vice-Presidents	28	Engineers Maint. of Way	89
General Managers	18	Bridge Engineers	28
Director Maint. and Operation	1	Engineers of Surveys	1
Asst. Director Maint. and Oper.	1	Tunnel Engineers	1
Assistant General Managers	6	Division Engineers	90
General Superintendents	10	Assistant Engineers	97
Asst. Gen. Superintendents	2	District Engineers	14
Division Superintendents	34	Electrical Engineers	4
Chief Engineers	114	Inspecting Engineers	11
Assistant Chief Engineers	24	Supervising Engineers	3
Principal Assistant Engineers	15	Architects	5
Chief Engineers Maint. of Way	6	Locating Engineers	3

Engineer Track Economics	1	General Foreman Water Works	1
Engineers Track and Roadway	5	Supervisor Materials	1
Designing Engineers	2	Chemists and Eng. Tests	2
Maint. of Way Accountant	1	Metallurgical Engineers	2
Engineer B. and B.	1	Engineer River Protection	1
Office Engineers	7	Professors in Colleges	16
Chief Draftsmen	5	Associate Professors	16
General Roadmasters	2	Government Employés	13
Roadmasters	14	Civil Engineers	59
Master Carpenters	3	Consulting Engineers	75
Rail Expert	1	Contracting Engineers	20
Supt. Bridges and Buildings	3	Engineer Grade Elimination	2
Supervisors	2	Purchasing Agent	1
Resident Engineers	30	General Agents	2
Signal Engineers	20	Receiver	1
Assistant Signal Engineer	1	Editors	3
Managers Timber Dept.	5	Miscellaneous	6
Chief Timber Inspector	1		
Forester	1	Total	967

LIBRARY.

The Board of Direction believes that the library of the Association can be made more effective as one of reference for the various Committees meeting from time to time at the Association's headquarters, as well as of greater interest and use to the membership in general. The practice of members communicating with the Secretary's office for data on various subjects pertaining to railway engineering or maintenance of way work is increasing, and it would be desirable to increase the facilities, in order that the information desired by the members or by Committees could be furnished promptly.

We already have the nucleus of a library in the form of bound volumes of certain transactions from other technical bodies. A list of the publications on file will appear in an early Bulletin for the information of the members.

The Board has extended an invitation to members to contribute any volumes that would be of interest to the membership, and these donations will be duly acknowledged in the Bulletin.

PUBLICATIONS.

During the year the following publications have been issued by the Association:

12 Bulletins.
Proceedings for 1910, in two volumes.
Proceedings for 1911, one volume (Part 2).
2 Editions of Specifications for Steel Railway Bridges.
Program for the Twelfth Annual Convention.

The table below indicates the number of pages, illustrations, etc., of the publications issued:

	No. Pages.	Half-Tones.	Folding Plates.	Diagrams.	Tables.
Bulletins	1,425	111	18	398	215
Proceedings, 1910	1,396	355	1	146	387
Proceedings, 1911	559	254	7	486	197
Steel Br. Spec.	32	....	....	4	2
Program	78	....	....	....	....

In addition to the above, approximately 400 pages of the revised Manual are in type. The issuance of the Manual has been postponed for the purpose of awaiting the action of the Twelfth Annual Convention on certain Committee reports, in order that this data may be included in the volume to be issued immediately after the adjournment of the convention.

FINANCIAL STATEMENT.

Balance on hand March 12, 1910		$15,382.57
Consisting of:		
Cash in bank	$6,403.01	
Four St. Louis Southwestern Railway Co. bonds, par value $1,000 each, at cost	3,319.31	
Six Lake Shore & Michigan Southern Railway Co. bonds, par value $1,000 each, at cost	5,660.25	
	$15,382.57	
Receipts during the year:		
From members	$11,645.25	
From others—sales of publications, advertising, etc.	5,145.92	
From American Railway Association, on account of Rail Committee expenditures	6,213.57	
From interest	457.46	
From loan	2,961.75	
Total receipts	$26,423.95	$26,423.95
Expenditures during the year		28,593.49
Excess of expenditures over receipts		$ 2,169.54

EXPENDITURES IN DETAIL.

Salaries	$ 4,003.01
Officers' expenses	10.15
Postage	447.96
Stationery and printing	699.81
Proceedings	3,987.11
Bulletins	5,538.89
Manual	50.50
Telephone and telegrams	107.20
Committee expenses	505.80
Annual meeting expenses	891.08
Rents	720.00
Equipment	175.35

Supplies	165.72
Light	11.14
Expressage	649.58
Exchange	33.00
Taxes	9.28
Impact tests	858.53
Rental of safety deposit box	5.00
Rail Committee expenditures	6,411.29
Refund of entrance fee and books returned	16.00
Rail joint tests	147.84
Miscellaneous (audit, floral tributes to deceased members, etc.)	108.00
Interest on temporary loan	41.25
Repayment of loan	3,000.00
Total	$28,593.49

Balance cash on hand March 15, 1911		$13,216.62
Consisting of:		
Ten railroad bonds, listed above, par value $10,000, at cost	$ 8,979.56	
Cash in Continental and Commercial National Bank, Chicago	4,237.06	
	$13,216.62	

IMPACT FUND.

Balance of Impact Test Fund on hand March 12, 1910	$2,823.01
Amount expended account of tests during year	858.53
Balance of fund	$1,964.48

Respectfully submitted,

E. H. Fritch, *Secretary.*

REPORT OF THE TREASURER.

To the Members of the American Railway Engineering and Maintenance of Way Association:

I have the honor to present the following report:

FINANCIAL STATEMENT.

Balance on hand March 12, 1910		$15,382.57
Consisting of:		
Four St. Louis Southwestern Railway Co. first mortgage 4 per cent. gold bonds, Nos. 1519, 1520, 1848 and 6463, par value $1,000 each, at cost	$ 3,319.31	
Six Lake Shore and Michigan Southern Railway Co. 4 per cent. bonds, Nos. 7463, 11112, 11113, 11114, 11115 and 11116, par value $1,000 each, at cost	5,660.25	
Cash in Continental and Commercial National Bank, Chicago	6,403.01	
		$15,382.57
Receipts from all sources, March 12, 1910, to March 15, 1911		$26,423.95
Amount paid out on audited vouchers		28,593.49
Excess of expenditures over receipts		$ 2,169.54

Balance on hand March 15, 1911 .... $13,216.62

Consisting of:

Ten railroad bonds listed above, par value $10,000, at cost .... $ 8,979.56

Cash in Continental and Commercial National Bank, Chicago.................. 4,237.60

$13,216.62

The bonds listed above are registered in the name of the Association and have been placed in a safety deposit box in the Merchants' Loan and Trust Company's vaults, Chicago.

Respectfully submitted,

C. F. LOWETH, *Treasurer.*

The President:—Gentlemen, you have heard the reports of the Secretary and Treasurer. What is your pleasure?

Mr. W. H. Elliott (New York Central & Hudson River):—I move their adoption.

(The motion was seconded and carried.)

Mr. William McNab (Grand Trunk):—Before the business of the convention begins, may I be allowed, Mr. President, through you, to express to the members of the Association the regret of Past-President Howard G. Kelley at his inability to be present at these sessions? Mr. Kelley is in Southern California, having taken his wife there in order to recuperate after a recent severe illness. May I say, also, Mr. President, that this is the first convention since the inception of the Association that Mr. Kelley has missed? His disappointment at his non-attendance is keen, but I do not think it is so in a greater degree than the members of this Association will feel at his absence. I ask your indulgence, Mr. President, in allowing me to make these remarks, so that Mr. Kelley's regrets may go on record.

The President:—The convention exceedingly regrets that Past-President Kelley is not able to be with us during this meeting, because his aid and advice in our proceedings have always been very valuable.

The next order of business is the presentation of reports of Standing and Special Committees. It is customary, as the committees are called, for the members to come forward promptly and take places on the platform.

The first Committee on the program is that on Rules and Organization, of which Mr. Jos. O. Osgood, Chief Engineer of the Central Railroad of New Jersey, is Chairman.

(The report of the Committee on Rules and Organization was presented by the Chairman of the Committee, Mr. Jos. O. Osgood. See report, Part 1, pp. 59-90; discussion, pp. 91-96.)

The President:—The next report is that of the Committee on Signals and Interlocking. We very much regret that Mr. A. H. Rudd, the Chairman of the Committee, is not able to attend the convention this year, and the report will be submitted by Mr. W. H. Elliott, a member of the Committee.

(The report of the Committee on Signals and Interlocking was then presented by Mr. W. H. Elliott, Signal Engineer, New York Central & Hudson River Railroad. See report, Part 1, pp. 97-129; discussion, pp. 131-134.)

The President:—The next report in order is that of the Committee on Electricity. Mr. George W. Kittredge, Chief Engineer of the New York Central & Hudson River Railroad, is Chairman of the Committee, and will present the report.

(The report of the Committee on Electricity was submitted by the Chairman, Mr. George W. Kittredge, Chief Engineer of the New York Central & Hudson River Railroad. See report, Part 1, pp. 135-220; discussion, pp. 221-230.)

The President:—The report of the Special Committee on Brine Drippings from Refrigerator Cars will be presented by the Chairman, Mr. J. C. Mock.

(The report of the Special Commitee on Brine Drippings from Refrigerator Cars was submitted by the Chairman, Mr. J. C. Mock, Electrical Engineer, Detroit Tunnel Company. See report, Part 1, pp. 231, 232; discussion, pp. 233, 234.)

The President:—The Railway Appliances Association has done itself proud this year in establishing one of the most instructive exhibits ever made, and it is due the Railway Appliances Association that we show our appreciation of their efforts and visit this exhibit as often as our time permits. Automobiles have been provided for the use of the members and their guests to run between the Congress Hotel and the Coliseum. On Wednesday afternoon, at four o'clock, the convention will adjourn for the purpose of giving opportunity to the members of the Association to visit the exhibit at the Coliseum.

An invitation has been received from the Chicago Engineers' Club, extending the facilities of that club to the members of this Association during their stay in the city.

The attendance at this first session has been very gratifying. Two hundred and forty-eight members have registered up to this time.

AFTERNOON SESSION.

The President:—The first order of business this afternoon is the consideration of the report of the Committee on Yards and Terminals. The report will be presented by Mr. F. S. Stevens, of the Philadelphia & Reading Railway.

(The report on Yards and Terminals was submitted by the Chairman, Mr. F. S. Stevens, Engineer Maintenance of Way, Philadelphia & Reading Railway. See report, Part 1, pp. 235-262; discussion, pp. 263-273.)

The President:—We will next consider the report of the Committee on Wooden Bridges and Trestles. The report will be presented by the Chairman, Prof. Henry S. Jacoby, of Cornell University.

(The report of the Committee on Wooden Bridges and Trestles was presented by the Chairman, Prof. Henry S. Jacoby, Cornell University. See report, Part 1, pp. 275-306; discussion, pp. 307-326.)

The President:—The next report to be considered is that of the Committee on Iron and Steel Structures, Mr. C. H. Cartlidge, Chairman.

(The report on Iron and Steel Structures was presented by the Chairman, Mr. C. H. Cartlidge, Bridge Engineer, Chicago, Burlington & Quincy Railway. See report, Part 3, pp. 9-317; discussion, pp. 318-332.)

WEDNESDAY, MARCH 22, 1911.

MORNING SESSION.

The President:—The convention will adjourn at 4 o'clock to-day, in order to give the members an opportunity to visit the railway appliances exhibition at the Coliseum. The exhibit is larger than in any previous year, and is one of great educational value.

The registration at this convention is very gratifying. The total registration yesterday was 358 members.

The first business before us this morning is the consideration of the report of the Committee on Ballast, Mr. John V. Hanna, Chief Engineer, Kansas City Terminal Railway, Chairman. In the absence of the Chairman and of the Vice-Chairman, Prof. S. N. Williams, a member of the Committee, will present the report.

(The report of the Committee on Ballast was submitted by Prof. S. N. Williams, of Cornell College, Iowa. See report, Part 1, pp. 339-346; discussion, pp. 347-355.)

The President:—The next report to be considered is that of the Committee on Economics of Railway Location, Mr. A. K. Shurtleff, of the Rock Island Lines, Chairman. In the absence of the Chairman, the report will be presented by Mr. R. N. Begien, Assistant to the General Manager, Baltimore & Ohio Railroad, a member of the Committee.

(The report of the Committee on Economics of Railway Location was submitted by Mr. R. N. Begien, Assistant to the General Manager, Baltimore & Ohio Railroad. See report, Part 1, pp. 327-335; discussion, pp. 336-338.)

The President:—We will next consider the report of the Committee on Ties, Mr. E. E. Hart, Chief Engineer of the New York, Chicago & St. Louis Railroad, Chairman. In the absence of the Chairman, the report will be presented by the Vice-Chairman, Mr. W. F. H. Finke.

(The report of the Committee on Ties was submitted by Mr. W. F. H. Finke, Tie and Timber Agent, Southern Railway. See report, Part 1, pp. 357-397; discussion, pp. 398-400.)

(Vice-President W. C. Cushing in the Chair during the consideration of the report on Ties.)

The President:—The report of the Committee on Rail will now be taken up for consideration. Mr. Charles S. Churchill, Chief Engineer, Norfolk & Western Railway, is Chairman, and will present the report.

(The report of the Committee on Rail was presented by the Chairman, Mr. Charles S. Churchill. See report, Part 2, pp. 3-599; discussion, Part 1, pp. 467-475.)

(Vice-President Cushing in the Chair during the consideration of the report on Track.)

Vice-President Cushing:—We will now take up the report of the Committee on Track. Mr. C. E. Knickerbocker is Chairman, and will present the report.

(The report of the Committee on Track was presented by Mr. C. E. Knickerbocker, Engineer Maintenance of Way, New York, Ontario & Western, Chairman. See report, Part 1, pp. 401-446; discussion, pp. 447-465.)

AFTERNOON SESSION.

(The consideration of the report on Track was continued at the afternoon session, with Vice-President Cushing in the Chair. At the close of the discussion on the report on Track, President Fritch resumed the Chair.)

The President:—The next order of business is the consideration of the report of the Committee on Masonry. Mr. W. H. Petersen is Chairman, and will present the report.

(The report of the Committee on Masonry was submitted by the Chairman, Mr. W. H. Petersen, Engineer Maintenance of Way, Chicago, Rock Island & Pacific Railway. See report, Part 1, pp. 477-578; discussion, pp. 579-586.)

THURSDAY, MARCH 23.

MORNING SESSION.

The President:—We have a large amount of business before us today, and it is suggested that all unessential matters be eliminated from the discussions as far as possible.

Before taking up the regular order of business, the Chair would ask unanimous consent to vary from the program slightly, and to have the result of the election of officers announced at the close of the morning session. There being no objection, the Chair would appoint the following members as Tellers: H. S. Wilgus, W. J. Bergen and C. H. Spencer. The Secretary will turn over the ballots to the Tellers, and they can retire to the anteroom and prepare their report.

The first report to be considered this morning is that of the Committee on Signs, Fences and Crossings.

(In the absence of the Chairman, the report was presented by the Vice-Chairman, Mr. K. J. C. Zinck, Grand Trunk Pacific Railway. See report, Part 3, pp. 613-615; discussion, p. 616.)

The next report will be that of the Committee on Water Service.

(The report was presented by the Chairman, Mr. C. L. Ransom, Resident Engineer, Chicago & Northwestern Railway. See report, Part 3, pp. 333-386; discussion, pp. 387-410.)

The President:—We will now consider the report of the Committee on Wood Preservation.

(In the absence of the Chairman, the report was presented by the Vice-Chairman, Mr. W. H. Courtenay, Chief Engineer, Louisville & Nashville Railroad. See report, Part 3, pp. 425-476; discussion, pp. 477-479.)

The President:—The report of the Committee on Buildings will be presented by the Vice-Chairman, Mr. Maurice Coburn, of the Vandalia Railroad.

(The report of the Committee on Buildings was presented by Mr. Coburn, the Vice-Chairman, in the absence of the Chairman of the Committee. See report, Part 1, pp. 587-622; discussion, pp. 623-625.)

The President:—We will next take up the report on Roadway.

(In the absence of the Chairman and Vice-Chairman, the report was presented by Prof. W. D. Pence, University of Wisconsin. See report, Part 3, pp. 481-542; discussion, pp. 543, 544.)

The President:—The report of the Committee on Records and Accounts is before you for consideration.

(The report of the Committee on Records and Accounts was presented by the Chairman, Mr. H. R. Safford. See report, Part 3, pp. 411-421; discussion, pp. 422-424.)

(The report of the Special Committee on Uniform General Contract Forms was called for, but no members of the Committee being present, the report was received as information. See report, Part 3, pp. 617-627.)

The President:—The next report to be considered is that of the Special Committee on Grading and Inspection of Maintenance of Way Lumber.

(The report was presented by the Chairman, Mr. W. H. Sellew, Principal Assistant Engineer, Michigan Central Railroad. See report, Part 3, pp. 545-606; discussion, pp. 607-612.)

(The report of the Committee on Conservation of Natural Resources was called for, and, on motion, was received as information. See report, Part 3, pp. 629-634.)

The President:—The Tellers appointed to canvass the ballots cast for officers for the current year have presented their report, and the Secretary will read it.

REPORT OF TELLERS OF ELECTION.

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Tellers appointed to canvass the votes for officers of the Association for the ensuing year beg leave to report the following result of the vote as canvassed:

Total number of votes cast	527
Votes not endorsed and not counted	11
Number of votes counted	516
For President:	
W. C. Cushing	512
G. H. Webb	2
M. L. Byers	1
For Vice-President:	
Edwin F. Wendt	507
Francis Lee Stuart	5
F. H. Alfred	1
A. S. Baldwin	1
Charles S. Churchill	1
For Secretary:	
E. H. Fritch	516
For Treasurer:	
George H. Bremner	515
D. J. Brumley	1
For Two Directors (three years each):	
A. S. Baldwin	505
C. F. Loweth	509
M. L. Byers	14
J. A. Atwood	2
Job Tuthill	1
A. F. Rust	1

Respectfully submitted,

(Signed) H. S. Wilgus,
W. J. Bergen,
C. H. Spencer,
Tellers.

The President:—The following are declared elected to the respective offices:

President—W. C. Cushing.
Vice-President—Edwin F. Wendt.
Secretary—E. H. Fritch.
Treasurer—George H. Bremner.
Two Directors—A. S. Baldwin, C. F. Loweth.

(Upon motion, the report of the Tellers was adopted.)

AFTERNOON SESSION.

The President:—The next order of business is "New Business." The subject that was brought up in the discussion this morning, in regard to the Manual, will be a fruitful topic for consideration. Before we proceed with that, I would like to quote from the fourth volume of the Proceedings the remarks made by the late Walter G. Berg:

"It is desirable for the Board of Direction to consider the question of appointing a Standing Committee on standard specifications and definitions, whose duty it shall be to prepare final standard specifications and definitions, based on the adopted reports of the various existing Standing or Special Committees on investigation, presented heretofore or to be presented hereafter to the Association; the work of this Committee to be in the nature of a Board of Review or Revision, so that it can present to the Association uniform and complete specifications or lists of definitions, which, if adopted by the Association, shall be known and published as the recommended standards of the Association." (Vol. 4, 1903, p. 461.)

That is really the germ of the thought which established our Manual of Recommended Practice. We all know that Mr. Berg, our valued member, was the father of the Manual of Recommended Practice, and it seemed to the Chair it would be well for the convention to have this expression read before the discussion begins.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I believe this is a matter that perhaps the Board of Direction really ought to settle, but I think the discussion by the membership at large would be enlightening to the Board.

In the interest of accuracy, I desire to make a correction in the statement the President has just made, without any idea of reflecting on the excellent work Mr. Berg did, but the Manual, as shown by the Minutes of the Board of Direction, will be found to have been first suggested by Mr. A. W. Sullivan, at that time our Vice-President. It was done in the earlier days of the Association, but was not put into effect until some time later.

Now, there seems to be quite a strong sentiment among a large number of our members that we should not publish a Manual as representing the selected subjects and matters which the Association has acted upon, and I think it is due to the Board of Direction to know if that sentiment is prevalent among our members, so that we can abandon the plan of adopting standards, and simply create ourselves into a body for the purpose of eliciting information from its members and publishing it broadcast. We have got to pursue either one course or the other, and I think it should be our aim, as expressed by Mr. Wendt this morning, to endeavor to promulgate specifications which can be used in securing competitive prices by the purchasing agents. That is one of the very useful things we will do in adopting specifications; but it seems impossible for this convention to analyze and discuss specifications of more than one or two committees at any one session, and the suggestion that a Board of Review be appointed for the purpose of finally passing upon these specifications, it seems to me, is an excellent one. I believe that the Board of Review should be appointed, but it should not be from the Board of Direction—it should be from the membership at large.

If the specifications we passed on to-day were placed in the hands of, say, three members, to recast and to endeavor to reconcile the different opinions expressed and then bring in revised specifications, I believe the Association would then be in position to adopt them. But my purpose in rising was to try and get some expression from the membership at large as to whether we were pursuing the right course or not in undertaking to present in one volume the best thought of our work throughout the year.

Mr. George W. Kittredge (New York Central & Hudson River) :—I should be very sorry indeed to see the Manual done away with. I appreciate, as Mr. McDonald has said, that it is very difficult for an Association with such a splendid attendance in number and in point of interest, to discuss thoroughly and put into final shape the reports of more than one or two committees. The remarks by the late Mr. Berg in regard to the Manual contain a good deal that is worth considering. The question of appointing a Board of Review, outside of the Board of Direction, is rather a new thought to me, but if such a Board could be obtained—and out of our large membership I have no doubt it could—I believe it would be better than to have it made a part of the duty of the Board of Direction. The members of the Board of Direction, when they get together, have a great many things to discuss. The work of editing and collecting, comparing and adjusting the various recommendations so that there will be no two in conflict, will take an enormous amount of time and careful study. While I had not thought of such a Board being named outside the Board of Direction, I think it is an excellent scheme. It is absolutely essential, now that our Manual has reached its present size, that it should be very carefully and closely edited in all its parts, so that the recommendations of one committee may not conflict with recommendations or conclusions of others. The time has come when such Board of Review is a necessity in the work of the Association.

Mr. McDonald:—In order to get an expression and discussion on the question of whether or not we shall publish a Manual, I move that we discontinue the publication of the Manual.

(The motion was seconded.)

Mr. G. D. Brooke (Baltimore & Ohio):—I agree with Mr. Kittredge that it would be a great loss, not only to the Association and all its members, but to the railroad world in general, to discontinue the publication of our Manual. While Mr. McDonald has made a motion to that effect, I feel quite sure that he would like to see it not carried. Now, the Manual goes all over America and to foreign countries, and is used as a reference book in practically all of the railway engineering offices in the country. I would regret very much to see the publication discontinued; but it would be a great advantage to have the subject-matter thoroughly reviewed and edited before being published, and all objectionable and conflicting matter either eliminated or brought into conformity.

The President:—The Chair would like to state its own opinion in this matter. It seems to the Chair hardly fair to the membership at large that such an important question as the publication of the Manual should be put to a vote of the convention, when a full representation is not present, and it seems to the Chair that it would be better to have the question submitted to letter-ballot instead of to a vote of a meeting representing only a portion of the membership.

Mr. McDonald:—There is no room in a letter-ballot for discussion. My object in making that motion was not so much to get a vote on it as to get the opinion of the members who have continually combated the idea of publishing a Manual. I think the members who consider it bad policy should give us their reasons; then it would be time enough to submit the question to letter-ballot.

Mr. M. L. Byers (Missouri-Pacific):—It seems to me the question of the desirability of the Manual is not entirely what some of us have in mind. The Manual, as a source of information, is a very desirable and useful thing, and it is very desirable that we shall continue to collect information of the character that we are placing in the Manual and bring it together as it is brought together in the Manual; but after we have done that, it seems to me there is another question, and that is the degree of backing that this Association shall give to what the Manual states is Recommended Practice. There are several reasons why it is not entirely desirable that we shall give too much backing to these recommendations. I think most of us have occasion to deal with the courts, and sometimes I think there has been an experience that the Manual can be used in such a way in the courts as to increase the difficulties of the engineer in dealing with the problems that he must confront in that way. The Manual is apt to be taken as being not a recommended practice, but *the only* recommended practice, that is perfectly good practice. Now, that is certainly not the case. There are many ways of doing many things well, and I do not think that this Association can afford to place its members in the position that it does if it says in the Manual that "this is the one way of doing this thing well." I think we must guard against that as one of the things in the consideration of how we are to treat this Manual proposition.

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis):—I think the Manual is a good thing. It is an incentive for the members of the several committees to get their work accepted for publication in that form; it seems quite difficult for committee-work to stand the test applied by the convention. The necessity for the Manual is to bring disjointed reports together in a volume where the net results of the work of the Association may easily be referred to. If the Manual were discontinued, it would be necessary to search through all the volumes of the Proceedings to find out what the Association thought about different questions. It has occurred to me that we might have two Manuals, if you please, but to change the name of one of them; call one the "Manual of Recommended Practice" and the other the "Digest of the Committees' Recommendations" or "Committee Reports," without putting the backing of the whole Association as the only recommended practice—but get the information where we can find it easily.

Mr. Robert Trimble (Pennsylvania Lines):—I want to ask just one question. What is the name of the title now? As I remember it, the Board of Direction struggled over the matter of a title for the Manual, and I would like to know what was decided upon at the meeting of the Board.

The President:—"Manual for Railway Engineering and Maintenance of Way"—the title of the volume would be "Manual for Railway Engineering and Maintenance of Way."

Mr. Trimble:—That was what we had in mind when that matter was discussed by the Board of Direction. We felt that we might have a title which would imply but one proper and only way of doing certain things, and that it might make trouble for some of the members of the Association, so the aim was to get a title for the Manual which would not imply that the practice embodied in the book was the only practice that might be acceptable. I think a great many of us think as Mr. Byers does, that there is more than one way of doing many things, and sometimes one way is as good as another, or there may be very little difference between two methods; but one thing we do want to guard against, and that is putting into the Manual something that has the force of fixing on the railroads but one method of procedure, when there are alternate methods that are just as good.

The President:—I might read the entire title: "Manual for Railway Engineering and Maintenance of Way, containing the definitions, specifications and principles of practice of the American Railway Engineering and Maintenance of Way Association, edited under the supervision of the Board of Direction."

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I am in accord with the remarks of Mr. Byers and Mr. Trimble. I am surprised that Mr. McDonald should make the motion he has, as it would certainly not seem wise for such an important question to be decided so quickly and by so small a representation as is present at this time. The Manual is good or bad, depending upon what is put into it. I think that this Association has formally adopted and put into the Manual some trivial and unwise things. The recommendations of committees have sometimes been adopted by the convention largely by sentiment, on the plea that the committee has done good work, and should be sustained; and at other times, and not infrequently, by a mere majority vote of the members present, of whom many did not vote either way. Discussion at these conventions of committee reports is certainly desirable, but it hardly appears to safeguard the Manual sufficiently. Perhaps it would be desirable to put nothing into the Manual until its approval by a majority vote of the membership of the Association by letter-ballot, and that only after previous consideration by the convention.

Mr. W. M. Camp (Railway and Engineering Review):—Mr. President, I am in favor of the Manual or something else to take its place. The Proceedings of this Association are now so extensive that it would be quite an undertaking for even one of our members to go through all of the volumes and pick out such matter as might be found pertaining to a given subject. If the Manual was not to be continued, I would be in favor of some kind of an index which would refer the reader to those volumes of the Proceedings in which any particular subject is treated.

As to the character of the Manual, I quite agree with the remarks which Mr. Wendt made this morning, to the effect that it should aim to cover mainly the fundamentals of the subject, or the underlying principles. If it is attempted to continue going into details as largely as has been the case heretofore, I am afraid that the Manual will not be successful, because we shall have to keep changing it every year or two. I think the idea of having a Board of Review to select the matter which should be put into the Manual is a good one, and we should discontinue the practice of having committees report expressly for the purpose of working up matter for insertion in the Manual. At this meeting, in nearly every report presented, there have been several reference stars with footnotes stating that the matter indicated was intended for insertion in the Manual.

Where a recommendation carries by a close vote, it ought to be pretty carefully considered whether it should go into the Manual or not; and I think it should be the purpose of the Board of Review to take account of the relative importance which might be imputed to those recommendations which pass by a unanimous vote, or by a large majority, or by a mere or doubtful majority, such as is often the case where the votes are estimated in the usual way by the volume of sound of the yeas and nays. Such scrutiny should be in line with the right principle for the selection of recommendations, and it would undoubtedly operate to cut down considerably the bulk of material which should go into the Manual.

There is another phase of this question which one or two previous speakers have referred to, and that is in regard to the responsibility of the Association in recommending certain things. I have seen, I do not know how many times, in these conventions, a very interesting discussion terminated by some member jumping up, with hands uplifted, and gravely giving warning that we should be careful what we did. He would wish to inquire what might be the consequences if our recommendation should be misconstrued in a case at court; or if we recommended a good thing so far in advance of the present state of the art, what might be the inference respecting the practice of a road which had not adopted the same good thing? Enough members would then be seized with sudden fright to either vote down the recommendation, or refer it back to the committee for more careful consideration, or to pass it in such amended form that the strength and vitality were completely removed.

The fact of the matter is that nearly every recommendation of a progressive character that we can make might be looked at in that light, for it is the habit of lawyers to misconstrue and misrepresent whenever they can turn a point to their advantage. But there is a way of spiking their guns, so to speak. It has been the experience of other associations heretofore that sometimes the recommendations made were taken with a wrong significance, and you will find in the proceedings of a number of technical associations a statement something like this: "The opinions expressed in this volume are the private opinions of members, and the Association, as a body, does not hold itself responsible for statements of that character."

I think it would be a splendid thing to print in the Manual, and also on the title page of the Proceedings of our Association, a notice to the effect that this Association would have it distinctly understood that practice which does not conform to the recommendations therein is not, for that reason, to be considered bad or incorrect practice. An understanding of that kind should remove any objection to recommending such methods, designs and other things as are found to be in line with progress.

Mr. C. H. Spencer (Washington Terminal Company):—I just want to say a word in regard to the legal aspect. I do not know whether or not the members of the Association are aware of it—this volume of recommended practice is not so far away from what we may be called upon to produce. At the last session of Congress, a bill was introduced by a Senator from Washington, which bill was carried over until the next session, authorizing the Interstate Commerce Commission to call upon the American Railway Association for a set of standards which would furnish a uniform standard for operation, signaling and maintenance of railways. That bill did not come up for action, but was carried over with other bills until the next session of Congress. So I do not know that we are working on wrong lines. There are two books that I keep on my desk—one is a set of standards furnished by our companies, the other is the Manual of Recommended Practice. On numerous occasions, during the past year, when recommendations have been made for work to be done, the inquiry has come into my office as to what was the latest recommendation made by the Maintenance of Way Association. Personally, I should very much regret to see the Manual of Recommended Practice discontinued, because it furnishes in condensed form the best opinions of the members of the Association.

Mr. Trimble:—May I ask for the reading of the notice which it is intended shall be published with the Manual of Recommended Practice and in our publications? If it is read, and we understand what it is, it might clear up some of this discussion.

The President:—The notice which the Board has decided upon is an extract from the Constitution, and reads as follows: "The object of this Association is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways. Its action is recommendatory, and not binding upon its members."

Mr. Trimble:—Is that what we discussed at the Board meetings during the year and agreed upon? We had that matter under discussion, and some of the members were to consult lawyers and agree on what was to be used.

The President:—The form as read is the last one agreed upon.

Mr. F. S. Stevens (Philadelphia & Reading):—It appears to be generally conceded that the Manual should be continued. It is also the general opinion, I think, that there should be a Board of Review or a Committee on Revision. Now, such a Board would be handicapped to some extent if constituted in the ordinary way, because the material to be reviewed is furnished by a number of committees. I would offer, therefore, as a suggestion, that a Board of Review should include, ex-officio, the chairmen of all committees, so that in the matter of review they would have an opportunity to be heard. I think that we should have also all Past-Presidents on such a Board, as these men have had the advantage of knowing everything that has passed during their terms of office, and possibly we should add some of the other officers. These would be ex-officio also. A Board constituted in this way would be able to review the Manual in a very satisfactory manner, I think, and greatly improve the value of the publication.

The President:—The remarks of Mr. Stevens certainly provide an answer to the problem of what to do with our ex-presidents.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—The Association issues three publications—the Bulletin, the Proceedings and the Manual. These publications cost under present conditions about $15,000 a year, and, as stated in the Treasurer's report, the Association ran behind last year $2,169. Some provision will have to be made either for getting authority to raise rates, or making a scientific reduction in expenses.

My idea is that the Bulletin should be printed as heretofore, but that all reports contained in the Bulletin should be before the members a definite number of months before they come before this convention for final approval of the recommendations. Under present conditions, Bulletins may reach the hands of the members thirty days before the convention at which these reports are to be discussed. We could well give consideration to a rule which would require that reports in Bulletin form should be in the hands of the membership for three or six or nine months before the convention, and that the Proceedings should not be burdened with reports until they have been thoroughly discussed before the convention. This would make for a reduction in the number of pages in the Proceedings and therefore a reduction in expense. Under present conditions we first pay for a page in the Bulletin and then we pay for the same page in the Proceedings. Therefore we do the same printing on two different occasions. If we could adopt a rule which would safeguard the reports, so that the members would come to the convention after having had these reports in their possession for three or six or nine months and having given consideration to these important matters, our minds would be in better condition for voting on the subject of the recommendations.

Respecting the Manual, at the present time the next issue of the Manual is in print, subject to the modifications that this convention will make. Therefore, the money has already been expended. I am strongly in favor of a continuation of the publication of the Manual, because it enables us to readily turn to the results of the work of the convention, without looking through the large number of volumes which are already on the shelves of the libraries. Furthermore, the Proceedings of this year will require three volumes instead of two last year and one volume in former years; so that the number of volumes of our Proceedings issued each year is increasing very rapidly.

Now, what ought the Manual to be? It ought to be an expression of the wisdom of the Association. It is not such to-day. There are conclusions in the Manual that do not represent the wisdom of the engineers of this country, and they have gotten into the Manual without due consideration. The legal responsibility of the Manual need hardly be considered except from this standpoint: If a lawyer undertook to introduce the Manual into court, he would be required by the rules of evidence approved by the courts to test the Manual by evidence, and unless he could prove by competent evidence that the principles outlined in our Manual were the common, ordinary and usual principles which governed railways in the district over which that court had jurisdiction, the Manual would have no standing. This is simply an application of the rules of evidence of the courts. We get into trouble to-day because some portions of our Manual have not been thoroughly considered. For illustration: An attorney 'phoned me sometime ago and asked, "Will you come over to court and testify for our company that the American Railway Engineering Association has decided that a certain clearance is required?" I said, "No, sir, I will not; firstly, because it has made no such decision; and secondly, if it had made any such decision it would be unwise." The attorneys are being told that there is such a thing in existence as a Manual, that is above reproach, that is infallible, that contains the wisdom of the engineers of the country. This is not the fact.

I think we should continue the Manual, but divest our minds of any thought of issuing it in a way to indicate that it represents that which is infallible, or that which does not admit of variable application. It seems to me that we could well afford to have a Manual that would contain standard specifications under which ballast can be purchased, standard specifications under which rails can be purchased; standard specifications for track bolts, nutlocks, spikes, screw-spikes, tie-plates, frogs, switches, guard-rails, etc.; specifications that would enable railways to get competition in the matter of prices, and standards that will enable railways to reduce their stock of materials.

While I am speaking on the subject of specifications, I want to say that in my judgment the specifications contained in our Proceedings are just as binding from the standpoint of responsibility when published in the Proceedings as when published in the Manual; and the specifications submitted by the Committee on Track for frogs and switches this year, and the specifications submitted last year, are the best specifications in print at the present time. I have compared them with the New York Central and Pennsylvania Lines specifications, and I make the above statement. So far as the Manual is concerned, we can well afford to delay the publication of these standard specifications until such time as we are confident that they are complete and that they represent the best practice under which railways could make purchases all over the country. I am of the opinion that we should reduce the number of pages in our Proceedings. A new rule should be put into effect with respect to the number of months which should intervene between the publication of committee reports and the consideration of these reports on this floor; and further, I am in favor of giving adequate time to the consideration of reports. For instance, the report of the Committee on Track should receive an ample number of hours of consideration, and those who have objections should come here and state them. The same remark applies to the specifications for water tanks. Let us give consideration to that which is up for final consideration and approval, but let us be sure that the reports have gone forth to the members a sufficient number of months in advance of the convention so that the members may come here fully prepared to give definite views.

I hope, gentlemen, that there will be no decision to discontinue the Manual, because the voluminous Proceedings of this Association require that there shall be a digest, and our Manual is nothing more than a hand-book—that is what the Manual is—a "hand-book;" what the lawyers call a "digest." We are simply following the practices of the American Railway Association, which issues a Red Book, sometimes called the rule book. We should divest our minds of the idea that the Manual commits us in any further degree from the standpoint of legal responsibility than the Proceedings.

I hope we will all come to the conclusion that it will be wise to have the Manual continued, because it enables us to refer quickly to the essential matter which had been considered by the Association.

Mr. M. L. Byers:—I move as an amendment to the motion before the house that the Board of Direction present to the Association a letter-ballot giving the members an opportunity to decide upon which one of the three following things they wish done:

(1) The abolishment of the Manual.

(2) The continuation of the Manual as at present.

(3) The continuation of the Manual in a modified form as suggested by the Board of Direction at the time of sending out these Bulletins.

(The motion was seconded.)

Mr. McDonald:—My object in making the motion was not to have it passed—I had no idea that it would be. I presented it simply to draw out discussion on the matter, and I think the discussion has been quite illuminating, and with the permission of my second I desire to withdraw the motion.

(Mr. McDonald's motion was withdrawn.)

The President:—The question is now on the motion of Mr. Byers.

Mr. McDonald:—When the question was first brought up in the meeting, it was felt that there was not a sufficient number of members present to decide the matter. My own opinion is that, instead of taking any action, the question should be delegated to the Board of Direction for such action as they see fit.

Mr. Kittredge:—I agree with Mr. McDonald's last remark. I know from my intimate association with the Board of Direction for a number of years the careful consideration that is given to subjects of that kind, and I know we can implicitly trust the Board, in view of all the discussion that has been had, to figure out in some way some plan that can be submitted to the Association at large which will be well worth their careful attention and consideration, and which will in the end bring forth the results desired. I do not believe in giving the Board instructions as to what they shall do, or what kind of plan they shall work out. They are in a position very much superior to that of any of the rest of us on the floor to know what is best for the Association, and I am confident that they will give such attention to the subject as it merits.

The President:—If the convention is satisfied, this matter will be referred to the Board of Direction for such action as it deems the interests of the Association warrant. If there is no further discussion on this question, we will proceed to other new business.

Mr. A. S. Baldwin (Illinois Central):—I desire to offer the following resolution:

"Resolved, That the members of the American Railway Engineering and Maintenance of Way Association, in annual convention assembled, desire to express their hearty appreciation of the efforts made and the admirable results obtained by the Railway Age Gazette, in its daily issue during the convention;

"Resolved, That the cordial thanks of the Association be extended to its managing officers and editorial staff;

"Resolved, That a copy of these resolutions be spread upon the Minutes of this convention, and a copy transmitted to the Railway Age Gazette."

(The resolution was carried unanimously.)

Mr. William McNab (Grand Trunk):—It will not do to place all the honors on one journal. We are fortunate in having another that has made a great record in reporting the proceedings of this Association since its inception, and I have much pleasure in proposing the following resolution:

"Resolved, That the members of the American Railway Engineering and Maintenance of Way Association, in annual convention assembled, desire to express their hearty appreciation of the efforts made and the admirable results obtained by the Railway and Engineering Review in its daily issue during this convention;

"Resolved, That the cordial thanks of the Association be extended to its managing officers and editorial staff;

"Resolved, That a copy of these resolutions be spread upon the Minutes of this convention, and a copy transmitted to the Railway and Engineering Review."

(The resolution was carried unanimously.)

Mr. W. M. Camp (Railway and Engineering Review):—I desire to offer the following resolution:

"Resolved, That the thanks of this Association be extended to the Automatic Annunciator Company for their courtesy in installing their device for the convenience of this convention."

(The resolution was adopted unanimously.)

Mr. Geo. H. Bremner (Chicago, Burlington & Quincy):—I wish to offer the following resolution:

"Resolved, That the members of the American Railway Engineering and Maintenance of Way Association, in convention assembled, desire to place on record their appreciation of the efforts made by the Railway Appliances Association in providing their instructive and comprehensive exhibit of devices used in railway construction, maintenance and operation, at the Coliseum during the week of the convention, and for the courtesies extended the members and railway men generally during the exposition."

(The resolution was adopted unanimously.)

Secretary E. H. Fritch:—I desire to offer the following resolution:

"Resolved, That the members of the American Railway Engineering and Maintenance of Way Association, in convention assembled, desire to place on record their appreciation of the efforts made by the Committee on Arrangements to minister to the comfort and entertainment of the members attending this convention, and that the thanks of the members are hereby extended to the Committee for their painstaking labors."

(The resolution was adopted unanimously.)

Mr. F. R. Coates (Inter-Ocean Steel Company):—The Committee on Arrangements appreciate the efforts of the President and of the officers of the Association. As the name of the Association is about to be changed, the Committee takes this opportunity to present to the retiring President, Mr. Fritch, the first pin with the new name.

The President:—I thank the Committee on Arrangements for their kind gift, and will wear it next to my heart. (Applause.)

The President:—The next order of business is the report on the result of the letter-ballot on amendments to the Constitution, including change of name of the Association.

The Secretary:—The revision of the Constitution was submitted to letter-ballot in two parts—first, the change in the name of the Association; second, for or against the remainder of the proposed amendments. The result of the letter-ballot is as follows:

Total number of votes cast	501
Ballot No. 1—Change of name:	
Yeas	463
Nays	37
Not voting	1
	501
Ballot No. 2—Remainder of amendments to Constitution:	
Yeas	480
Nays	21
	501

(See Revised Constitution, pp. 43-56.)

The President:—The change in the name and the amendments to the Constitution have both carried. The change in the name and the other amendments take effect thirty days after the adjournment of this convention. The new name of the Association will be "American Railway Engineering Association."

The next order of business, if there is no further new business, is the installation of officers. The result of the vote on officers has already been announced.

In retiring from the office of President, I simply want to say that I have tried to do my duty to the best of my ability. The office of President of this Association is not a sinecure, if the duties are performed faithfully and conscientiously, and the work grows harder each year. The Association has been fortunate in its methods, in having the office of President rotate, so that the senior members of the Board of Direction represent your Past-Presidents. By this means you have men in charge of the affairs of your Association who have had years of experience in its work, and this has proved a wise policy. I want to thank the members of the Association, the Board of Direction and the Secretary's staff for the kind assistance which they have given me during the year. (Applause.)

I will appoint Mr. Churchill and Mr. Wendt a Committee to escort to the platform your new President, Mr. W. C. Cushing. (Applause.)

President-Elect Cushing:—I am not going to make any speech, gentlemen. I simply want to thank you for the honor you have conferred upon me. (Applause.)

Mr. A. W. Johnston (New York, Chicago & St. Louis):—Before we adjourn, I would like to offer a resolution. Mr. Fritch was quite modest in his final remarks treating of his course as our President, and I think we should put on record a more formal expression of appreciation of this Association for his year's arduous work. I offer the following resolution:

"Resolved, That this Association places on record its deep appreciation of the untiring efforts, zeal, wise business judgment and good sense which has characterized the administration of the retiring President, Mr. L. C. Fritch."

President Cushing:—We will rise in acknowledgment of the resolution of Mr. Johnston.

(The resolution was adopted unanimously by a rising vote.)

President Cushing:—Mr. Fritch, the thanks of the Association are extended to you.

Past-President Fritch:—I thank you.

President Cushing:—If there is no further business before the meeting, the convention will stand adjourned sine die.

The Thirteenth Annual Convention of the American Railway Engineering Association will be held at the Congress Hotel and Annex, Tuesday, Wednesday and Thursday, March 19, 20 and 21, 1912.

E. H. FRITCH,
Secretary.

CONSTITUTION

CONSTITUTION.

REVISED AT THE FIFTH, EIGHTH AND TWELFTH ANNUAL CONVENTIONS.

ARTICLE I.

NAME, OBJECT AND LOCATION.

1. The name of this Association is the AMERICAN RAILWAY ENGINEERING ASSOCIATION. Name.

2. Its object is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways. Object.

3. The means to be used for this purpose shall be as follows: Means to be Used.

(a) Meetings for the reading and discussion of reports and papers and for social intercourse.

(b) The investigation of matters pertaining to the objects of this Association through Standing and Special Committees.

(c) The publication of papers, reports and discussions.

(d) The maintenance of a library.

4. Its action shall be recommendatory, and not binding upon its members. Responsibility.

5. Its permanent office shall be located in Chicago, Ill., and the annual convention shall be held in that city. Location of Office.

ARTICLE II.

MEMBERSHIP.

1. The membership of this Association shall be divided into three classes, viz.: Members, Honorary Members and Associates. Membership Classes.

(2) A Member shall be: Membership Qualifications.

(a) Either a Civil Engineer, a Mechanical Engineer, an Electrical Engineer, or an official of a railway corporation, who has had not less than five (5) years' experience in the location, construction, maintenance or operation of railways, and who, at the time of application for membership, is engaged in railway service in a responsible position in charge of work connected with the Location, Construction, Operation or Maintenance of a Railway; provided, that all persons who were Active Members prior to March 20, 1907, shall remain Members except as modified by Article II, Clause 9.

(b) A Professor of Engineering in a college of recognized standing.

Honorary Membership Qualifications.

3. An Honorary Member shall be a person of acknowledged eminence in railway engineering or management. The number of Honorary Members shall be limited to ten.

Associate Membership Qualifications.

4. An Associate shall be a person not eligible as a Member, but whose pursuits, scientific acquirements or practical experience qualify him to co-operate with Members in the advancement of professional knowledge, such as Consulting, Inspecting, Contracting, Government or other Engineers, Instructors of Engineering in Colleges of recognized standing, and Engineers of Industrial Corporations when their duties are purely technical.

Membership Rights.

5. (a) Members shall have all the rights and privileges of the Association.

(b) Honorary Members shall have all the rights of Members, except that of holding office, and shall be exempt from the payment of dues.

(c) Associates shall have all the rights of Members, except those of voting and holding office.

Age Requirement.

6. An applicant to be eligible for membership in any class shall not be less than twenty-five (25) years of age.

"Railway" Defined.

7. The word "railway" in this Constitution means one operated by steam or electricity as a common carrier, dependent upon transportation for its revenue. Engineers of street railway systems and of railways which are used primarily to transport the material or product of an industry or industries to and from a point on a railway which is a common carrier, or those which are merely adjuncts to such industries, are eligible only as Associates.

Changes in Classes.

8. A Member, elected after March 20, 1907, who shall leave the railway service, shall cease to be a Member, but may retain membership in the Association as an Associate, subject to the provisions of Article II, Clause 9; provided, however, if he re-enters the railway service, he shall be restored to the class of Members.

Supply Men.

9. Persons whose principal duties require them to be engaged in the sale or promotion of railway patents, appliances or supplies, shall not be eligible for, nor retain membership in any class in this Association, except that those who were Active Members prior to March 20, 1907, may retain membership as Associates; provided, however, that anyone having held membership in the Association and subsequently having become subject to the operation of this clause, shall, if he again becomes eligible, be permitted to re-enter the Association, without the payment of a second entrance fee.

Transfers.

10. The Board of Direction shall transfer members from one class to another, or remove a member from the membership list, under the provisions of this Article.

ARTICLE III.

ADMISSIONS AND EXPULSIONS.

Charter Membership.

1. The Charter Membership consists of all persons who were elected before March 15, 1900.

2. The Charter Membership having been completed, any person desirous of becoming a member shall make application upon the form prescribed by the Board of Direction, setting forth in a concise statement his name, age, residence, technical education and practical experience. He shall refer to at least three members to whom he is personally known, each of whom shall be requested by the Secretary to certify to a personal knowledge of the candidate and his fitness for membership. Application for Membership.

3. Upon receipt of an application properly endorsed, the Board of Direction, through its Secretary, or a Membership Committee selected from its own members, shall make such investigation of the candidate's fitness as may be deemed necessary. The Secretary will furnish copies of the information obtained and of the application to each member of the Board of Direction. At any time, not less than thirty days after the filing of the application, the admission of the applicant shall be canvassed by letter-ballot among the members of the Board, and affirmative votes by two-thirds of its members shall elect the candidate; provided, however, that should an applicant for membership be personally unknown to three members of the Association, due to residence in a foreign country, or in such a portion of the United States as precludes him from a sufficient acquaintance with its members, he may refer to well-known men engaged in railway or allied professional work, upon the form above described, and such application shall be considered by the Board of Direction in the manner above set forth, and the applicant may be elected to membership by a unanimous vote of the Board. Election to Membership.

4. All persons, after due notice from the Secretary of their election, shall subscribe to the Constitution on the form prescribed by the Board of Direction. If this provision be not complied with within six months of said notice, the election shall be considered null and void. Subscription to Constitution.

5. Any person having been a member of this Association, and having, while in good standing, resigned such membership, may be reinstated without the payment of a second entrance fee; provided his application for reinstatement is signed by five members certifying to his fitness for same, and such application is passed by a two-thirds majority of the Board of Direction. Reinstatement.

6. Proposals for Honorary Membership shall be submitted by ten or more Members. Each Member of the Board of Direction shall be furnished with a copy of the proposal, and if, after thirty days, the nominee shall receive the unanimous vote of said Board, he shall be declared an Honorary Member. Honorary Membership.

7. When charges are preferred against a Member in writing by ten or more Members, the Member complained of shall be served with a copy of such charges, and he shall be called upon to show cause to the Board of Direction why he should not be expelled from the Association. Not less than thirty days thereafter a vote shall be taken on his expulsion, and he shall be expelled upon a two-thirds vote of the Board of Direction. Expulsions.

8. The Board of Direction shall accept the resignation, tendered in writing, of any Member whose dues are fully paid up. Resignations

ARTICLE IV.

DUES.

Entrance Fee.

1. An entrance fee of $10.00 shall be payable to the Association through its Secretary with each application for membership; and this sum shall be returned to the applicant if not elected.

Annual Dues.

2. The annual dues are $10.00, payable during the first three months of the calendar year.

Arrears.

3. Any person whose dues are not paid before April 1st of the current year shall be notified of same by the Secretary. Should the dues not be paid prior to July 1st, the delinquent Member shall lose his right to vote. Should the dues remain unpaid October 1st, he shall be notified on the form prescribed by the Board of Direction, and he shall no longer receive the publications of the Association. If the dues are not paid by December 31st, he shall forfeit his membership without further action or notice, except as provided for in Clause 4 of this Article.

Remission of Dues.

4. The Board of Direction may extend the time of payment of dues, and may remit the dues of any Member, who, from ill-health, advanced age or other good reasons, is unable to pay them.

ARTICLE V.

OFFICERS.

Officers.

1. The officers of the Association shall be Members and shall consist of:

A President,
A First Vice-President,
A Second Vice-President,
A Treasurer,
A Secretary,
Nine Directors,

who, together with the five latest living Past-Presidents who are Members, shall constitute the Board of Direction in which the government of the Association shall be vested, and who shall act as Trustees, and have the custody of all property belonging to the Association.

Vice-Presidents' Priority.

2. The offices of First and Second Vice-Presidents shall be determined by the priority of their respective dates of election.

Terms of Office.

3. The terms of office of the several officers shall be as follows:

President, one year.
Vice-Presidents, two years.
Treasurer, one year.
Secretary, one year.
Directors, three years.

Officers Elected Annually.

4. (a) There shall be elected at each Annual Convention:

A President,
One Vice-President,
A Treasurer,
A Secretary,
Three Directors.

(b) The candidates for President and for Vice-President shall be selected from the members of the Board of Direction.

5. The office of President shall not be held twice by the same person. A person who shall have held the office of Vice-President or Director shall not be eligible for re-election to the same office until at least one full term shall have elapsed after the expiration of his previous term of office. Conditions of Re-election of Officers.

6. The term of each officer shall begin with his election and continue until his successor is elected. Term of Officers.

7. (a) A vacancy in the office of President shall be filled by the First Vice-President. Vacancies in Offices.

(b) A vacancy in the office of either of the Vice-Presidents shall be filled by the Board of Direction by election from the Directors. A Vice-Presidency shall not be considered vacant when one of the Vice-Presidents is filling a vacancy in the Presidency.

(c) Any other vacancies for the unexpired term in the membership of the Board of Direction shall be filled by the Board.

(d) An incumbent in any office for an unexpired term shall be eligible for re-election to the office he is holding; provided, however, that anyone appointed to fill a vacancy as Director within six months after the term commences shall be considered as coming within the provision of Article V, Clause 5.

8. When an officer ceases to be a Member of the Association, as provided in Article II, his office shall be vacated, and be filled as provided in Article V, Clause 7. Vacation of Office.

9. In case of the disability or neglect in the performance of his duty, of an officer, the Board of Direction, by a two-thirds majority vote of the entire Board, shall have power to declare the office vacant, and fill it as provided in Article V, Clause 7. Disability or Neglect.

ARTICLE VI.

NOMINATION AND ELECTION OF OFFICERS.

1. (a) There shall be a Nominating Committee composed of the five latest living Past-Presidents of the Association, who are Members, and five Members not officers. Nominating Committee.

(b) The five Members shall be elected annually when the officers of the Association are elected.

2. It shall be the duty of this committee to nominate candidates to fill the offices named in Article V, and vacancies in the Nominating Committee caused by expiration of term of service, for the ensuing year, as follows: Number of Candidates

Office to be Filled.	Number of Candidates to be named by Nominating Committee.	Number of Candidates to be elected at Annual Election of Officers.
President	1	1
Vice-President	1	1
Treasurer	1	1
Secretary	1	1
Directors	9	3
Nominating Committee	10	5

Chairman.

3. The Senior Past-President shall act as permanent chairman of the committee, and will issue the call for meetings. In his absence from meetings, the Past-President next in age of service shall act as Chairman pro tem. at the meeting.

Meeting of Committee.

4. Prior to December 1st, each year, the Chairman shall call a meeting of the committee at a convenient place and, at this meeting, nominees for office shall be agreed upon.

Announcement of Names of Nominees.

5. The names of the nominees shall be announced by the permanent Chairman to the President and Secretary not later than December 15th of the same year, and the Secretary shall report them to the Members of the Association on a printed slip not later than January 1st following.

Additional Nominations by Members.

6. At any time between January 1st and February 1st, any ten or more Members may send to the Secretary additional nominations for the ensuing year signed by such Members.

Vacancies in List of Nominees.

7. If any person so nominated shall be found by the Board of Direction to be ineligible for the office for which he is nominated, or should a nominee decline such nomination, his name shall be removed and the Board may substitute another one therefor; and may also fill any vacancies that may occur in this list of nominees up to the time the ballots are sent out.

Ballots Issued.

8. Not less than thirty days prior to each Annual Convention, the Secretary shall issue ballots to each voting member of record in good standing, with a list of the several candidates to be voted upon, with the names arranged in alphabetical order when there is more than one name for any office.

Substitution of Names.

9. Members may erase names from the printed ballot list and may substitute the name or names of any other person or persons eligible for any office, but the number of names voted for each office on the ballot must not exceed the number to be elected at that time to such office.

Ballots.

10. (a) Ballots shall be placed in an envelope, sealed and endorsed with the name of the voter, and mailed or deposited with the Secretary at any time previous to the closure of the polls.

(b) A voter may withdraw his ballot, and may substitute another, at any time before the polls close.

Invalid Ballots.

11. Ballots not endorsed or from persons not qualified to vote shall not be opened; and any others not complying with the above provisions shall not be counted.

Closure of Polls.

12. The polls shall be closed at twelve o'clock noon on the second day of the Annual Convention, and the ballots shall be counted by three tellers appointed by the Presiding Officer. The ballots and envelopes shall be preserved for not less than ten days after the vote is canvassed.

Requirements for Election.

13. The persons who shall receive the highest number of votes for the offices for which they are candidates shall be declared elected.

Tie Vote.

14. In case of a tie between two or more candidates for the same office, the members present at the Annual Convention shall elect the officer by ballot from the candidates so tied.

15. The Presiding Officer shall announce at the convention the names of the officers elected in accordance with this Article. Announcement.

16. Except as to the Past-Presidents, the first Nominating Committee and the three additional Directors provided for shall be appointed by the Board of Direction, one of the Directors for one year, one for two years, and one for three years. First Nominating Committee.

ARTICLE VII.

MANAGEMENT.

1. (a) The President shall have general supervision of the affairs of the Association, shall preside at meetings of the Association and of the Board of Direction, and shall be ex-officio member of all Committees, except the Nominating Committee. Duties of President.

(b) The Vice-Presidents, in order of seniority, shall preside at meetings in the absence of the President and discharge his duties in case of a vacancy in his office.

2. The Treasurer shall receive all moneys and deposit same in the name of the Association, and shall receipt to the Secretary therefor. He shall invest all funds not needed for current disbursements as shall be ordered by the Board of Direction. He shall pay all bills, when properly certified and audited by the Finance Committee, and make such reports as may be called for by the Board of Direction. Duties of Treasurer.

3. The Secretary shall be, under the direction of the President and Board of Direction, the Executive Officer of the Association. He shall attend the meetings of the Association and of the Board of Direction, prepare the business therefor, and duly record the proceedings thereof. He shall see that the moneys due the Association are collected and without loss transferred to the custody of the Treasurer. He shall personally certify to the accuracy of all bills or vouchers on which money is to be paid. He is to conduct the correspondence of the Association and keep proper record thereof, and perform such other duties as the Board of Direction may prescribe. Duties of Secretary.

4. The accounts of the Treasurer and Secretary shall be audited annually by a public accountant, under the direction of the Finance Committee of the Board. Auditing of Accounts.

5. The Board of Direction shall manage the affairs of the Association, and shall have full power to control and regulate all matters not otherwise provided in the Constitution. Duties of Board.

6. The Board of Direction shall meet within thirty days after each Annual Convention, and at such other times as the President may direct. Special meetings shall be called on request, in writing, of five members of the Board. Board Meetings.

7. Seven members of the Board shall constitute a quorum. Board Quorum.

8. At the first meeting of the Board after the Annual Convention, the following committees from its members shall be appointed by the President, and shall report to and perform their duties under the supervision of the Board of Direction: Board Committees.

a. Finance Committee of three members.
b. Publication Committee of three members.
c. Library Committee of three members.
d. Outline of Work of Standing Committees of five members.

Duties of Finance Committee.

9. The Finance Committee shall have immediate supervision of the accounts and financial affairs of the Association; shall approve all bills before payment, and shall make recommendations to the Board of Direction as to the investment of moneys and as to other financial matters. The Finance Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money other than the amounts necessary to meet ordinary current expenses of the Association, except by previous action and authority of the Board of Direction.

Duties of Publication Committee.

10. The Publication Committee shall have general supervision of the publications of the Association.

Duties of Library Committee.

11. The Library Committee shall have general supervision of the Library, the property therein, and the quarters occupied by the Secretary; shall make recommendations to the Board with reference thereto, and shall direct the expenditure for books and other articles of permanent value, from such sums as may be appropriated for these purposes.

Duties of Committee on Outline of Work of Standing Committees.

12. The Committee on Outline of Work of Standing Committees shall present a list of subjects for committee work during the ensuing year at the first meeting of the Board of Direction after the Annual Convention.

Standing Committees.

13. The Board of Direction may appoint such Standing Committees as it may deem best, to investigate, consider and report upon questions pertaining to railway location, construction or maintenance.

Special Committees.

14. Special Committees to examine into and report upon any subject connected with the objects of this Association may be appointed from time to time by the Board of Direction.

Discussion by Non-Members.

15. The Board of Direction may invite discussions of reports from persons not members of the Association.

Sanction of Acts of Board.

16. An act of the Board of Direction which shall have received the expressed or implied sanction of the membership at the next Annual Convention of the Association shall be deemed to be the act of the Association, and shall not afterwards be impeached by any Member.

ARTICLE VIII.

MEETINGS.

Annual Convention.

1. The Annual Convention shall begin upon the third Tuesday in March of each year, and shall be held at such place in the City of Chicago as the Board of Direction may select.

Special Meetings.

2. Special meetings of the Association may be called by the Board of Direction, and special meetings shall be so called by the Board upon request of thirty Members, which request shall state the purpose of such meeting. The call for such meeting shall be issued not less than ten days in advance, and shall state the purpose and place thereof, and no other business shall be taken up at such meeting.

3. The Secretary shall notify all members of the time and place of the Annual Convention of the Association at least thirty days in advance thereof. Notification of Annual Convention.

4. Twenty-five Members shall constitute a quorum at all meetings of the Association. Association Quorum.

5. (a) The order of business at annual conventions of the Association shall be as follows: Order of Business.

Reading of minutes of last meeting.
Address of the President.
Reports of the Secretary and Treasurer.
Reports of Standing Committees.
Reports of Special Committees.
Unfinished business.
New business.
Election of officers.
Adjournment.

(b) This order of business, however, may be changed by a majority vote of members present.

6. The proceedings shall be governed by "Robert's Rules of Order," except as otherwise herein provided. Rules of Order.

7. Discussion shall be limited to members and to those invited by the presiding officer to speak. Discussion.

ARTICLE IX.

AMENDMENTS.

1. Proposed amendments to this Constitution shall be made in writing and signed by not less than ten Members, and shall be acted upon in the following manner: Amendments

The amendments shall be presented to the Secretary, who shall send a copy of same to each member of the Board of Direction as soon as received. If at the next meeting of the Board of Direction a majority of the entire Board are in favor of considering the proposed amendments, the matter shall then be submitted to the Association for letter-ballot, and the result announced by the Secretary at the next Annual Convention. In case two-thirds of the votes received are affirmative, the amendments shall be declared adopted and become immediately effective.

GENERAL INFORMATION.

(Subject to change from time to time by Board of Direction.)

GENERAL RULES FOR THE PREPARATION, PUBLICATION AND CONSIDERATION OF COMMITTEE REPORTS.

(A) APPOINTMENT OF COMMITTEES AND OUTLINE OF WORK.

Standing Committees.

1. The following are standing committees:

I. Roadway.
II. Ballast.
III. Ties.
IV. Rail.
V. Track.
VI. Buildings.
VII. Wooden Bridges and Trestles.
VIII. Masonry.
IX. Signs, Fences and Crossings.
X. Signals and Interlocking.
XI. Records and Accounts
XII. Rules and Organization.
XIII. Water Service.
XIV. Yards and Terminals.
XV. Iron and Steel Structures.
XVI. Economics of Railway Location.
XVII. Wood Preservation.
XVIII. Electricity.
XIX. Conservation of Natural Resources.

Special Committees.

2. Special Committees will be appointed from time to time, as may be deemed expedient, in the manner prescribed by Article VII, Clause 14, of the Constitution.

Personnel of Committees.

3. The personnel of all Committees will continue from year to year, except when changes are announced by the Board of Direction at the annual convention.

Outline of Work.

4. As soon as practicable after each annual convention the Board of Direction will assign to each Committee the important questions which, in its judgment, should preferably be considered during the current year. Committees are privileged to present the results of any special study or investigation they may be engaged upon or that may be considered of sufficient importance to warrant presentation.

(B) PREPARATION OF COMMITTEE REPORTS.

General.

5. The collection and compilation of data and subsequent analysis in the form of arguments and criticism is a necessary and valuable preliminary element of committee work.

6. Committees are privileged to obtain data or information in any proper way. If desired, the Secretary will issue circulars of inquiry, which should be brief and concise. The questions asked should be specific and pertinent, and not of such general or involved character as to preclude the possibility of obtaining satisfactory and prompt responses. They should specify to whom answers are to be sent, and should be in such form that copies can be retained by persons replying either by typewriter or blue-print. **Collection of Data.**

7. Committee reports should be prepared as far as practicable to conform to the following general plan: **Plan of Reports.**

(a) It is extremely important that every Committee should examine its own subject-matter in the "Manual" prior to each annual convention, and revise and supplement it, if deemed desirable, giving the necessary notice of any recommended changes in accordance with Clause 6 (a) of the General Rules for the Publication of the "Manual of the Proceedings." If no changes are recommended, statement should be made accordingly.

(b) The report should be prefaced by a condensed statement of meetings held and members in attendance; also, personnel of sub-committees appointed.

(c) The previous report should be reviewed, describing action taken thereon, referring briefly in order to all conclusions, specifications or standards then adopted, giving volume and page of Proceedings and Manual.

(d) Subjects presented in previous reports on which no action was taken should be resubmitted, stating concisely the action desired. It may not be necessary to repeat the original text in the report, reference to former publication being sufficient, unless changes in the previously published version are extensive. Minor changes can be explained in the text of the report.

(e) Technical terms used in the report, the meaning of which is not clearly established, should be submitted, but defined only from the standpoint of railway engineering. **Definitions.**

(f) If necessary, a brief history of the subject-matter under discussion, with an outline of its origin and development, should be given. **History.**

(g) An analysis of the most important elements of the subject-matter should be given. **Analysis.**

(h) The advantages and disadvantages of the present and recommended practices should be set forth. **Argument.**

(i) Illustrations accompanying reports should be prepared so that they can be reproduced on one page. The use of folders should be avoided as much as possible, on account of the increased expense and inconvenience in referring to them. **Illustrations.**

Illustrations should be made on tracing cloth with heavy black lines and figures, so as to stand a two-thirds reduction; for example: To come within a type page (4 inches by 7 inches), the illustration should be made three times the above size.

To insure uniformity, the one-stroke, inclined Gothic lettering is recommended.

Photographs should be clear and distinct silver prints.

Conclusions. (j) The conclusions of the Committee which are recommended for publication in the Manual of the Proceedings should be stated in clear, concise and comprehensive language, in logical sequence, and grouped together, in boldface type, specifying the plans, specifications, definitions, forms, tables and formulas included in the recommendation. Portions of the text of the report which are absolutely essential to a clear interpretation and understanding of the conclusions should be included as an integral part thereof.

Signatures. (k) Committee reports, when practicable, should be signed by each member of the Committee; but where this might cause delay, the Chairman may sign for the members, after obtaining their consent. The report, when published, will contain only the names of such members of the Committee complying with this rule.

(c) PUBLICATION OF COMMITTEE REPORTS.

Reports Required. 8. (a) Reports will be required from each of the Standing and Special Committees each year.

(b) Although several subjects may be assigned to each Committee, not more than two subjects will be submitted for action by the convention, unless otherwise arranged by the Board of Direction. The object of assigning several subjects is to enable the committees to make selections, and to begin the preparation of data for some subjects, which often requires considerable time for their proper preparation and consideration.

Date of Filing Reports. 9. Committee reports to come before the succeeding convention for discussion should be filed with the Secretary not later than November, 30 of each year.

10. Committees engaged upon subjects involving an extended investigation and study are privileged to present progress reports, giving a brief statement of the work accomplished, and, if deemed expedient, a forecast of the final report to be presented.

Publication of Reports. 11. Committee reports will be published in the Bulletin in such sequence as the Board of Direction may determine, but not later than February 15 of each year, for consideration at the succeeding convention. Reports will be published in the Proceedings in the form presented by the respective Committees. Alterations ordered by the convention will be printed in the form of footnotes or as an appendix to the report.

Written Discussions. 12. Committees should endeavor to secure written discussions of published reports. Written discussions will be transmitted to the respective Committees, and if deemed desirable by the Committee, the discussions will be published prior to the convention and be considered in connection with the report.

Verbal Discussions. 13. Each speaker's remarks will be submitted to him in writing before publication in the Proceedings, for the correction of diction and errors of reporting, but not for the elimination of remarks.

(D) CONSIDERATION OF COMMITTEE REPORTS.

14. The sequence in which Committee reports will be considered by the convention will be determined by the Board of Direction. Sequence.

15. The method of consideration of Committee reports will be one of the following: Method.

(a) Reading by title.

(b) Reading, discussing and acting upon each conclusion separately.

(c) By majority vote, discussion will be had on each item. Clauses not objected to when read will be considered as voted upon and adopted.

16. Action by the convention on Committee reports will be one of the following, after discussion is closed: Final Action.

(a) Receiving as information.

(b) Receiving as a progress report and referring back to Committee.

(c) Adoption of a portion and referring remainder back to Committee.

(d) Adoption as amended.

(e) Adoption as submitted.

GENERAL RULES FOR THE PUBLICATION OF THE "MANUAL."

Title.

1. The title of the volume will be "Manual of the American Railway Engineering Association," edited under the supervision of the Board of Direction.

2. The Board of Direction shall have authority to exclude from the Manual any matter which, in its judgment, it shall consider as not desirable to publish, or as not being in proper shape, or as not having received proper study and consideration.

Adoption of Reports Not Binding.

3. The adoption by the Association and subsequent publication of any matter in the Manual shall be considered in the nature of principles of good practice, and shall not be binding on the members.

Contents.

4. The Manual will only include resolutions, conclusions, recommendations, plans, etc., relating to definitions, specifications or principles of practice of such questions connected with railway engineering and maintenance of way work which have been made the subject of a special study by a Standing or Special Committee and embodied in a committee report, published not less than thirty days prior to the annual convention, and submitted by the Committee to the annual convention, and which, after due consideration and discussion, shall have been voted on and formally adopted by the Association; subjects which, in the opinion of the Board of Direction, should be reviewed by the American Railway Association, may be referred to that Association before being published in the Manual.

5. All resolutions, conclusions, recommendations, specifications, standards, etc., in order to be included in the Manual, must be in concise and proper final shape for publication, as the Manual will consist only of a summary record of the definitions, principles of practice, specifications and standards acted upon by the Association, with a brief reference to the published Proceedings of the Association for the context of the Committee report and subsequent discussion and the final action of the Association.

Revision.

6. Any matter published in the Manual may be amended, revised, extended or withdrawn by vote at any subsequent annual convention, provided such changes are proposed in time for publication not less than thirty days prior to the annual convention, and in the following manner: (a) Upon recommendation of the Committee in charge of the subject; (b) upon recommendation of the Board of Direction; (c) upon request of five members, subject to the action of the Board of Direction under Rule 2.

7. The Manual will be revised annually and kept up to date by publishing a new edition or a supplemental pamphlet as promptly as possible after each annual convention.

COMMITTEE
REPORTS AND DISCUSSIONS

REPORT OF COMMITTEE XII.—ON RULES AND ORGANIZATION.

(Bulletin 129.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Meetings of the Committee were held as follows:

Friday, July 22, at New York. Those present were: F. D. Anthony, G. D. Brooke, S. E. Coombs, G. L. Moore and Jos. O. Osgood. A letter was received from D. B. Johnston.

Friday, October 28, at New York. Those present were: F. D. Anthony and Jos. O. Osgood. Letters were received from G. D. Brooke, D. B. Johnston, G. L. Moore and F. L. Nicholson.

Friday, December 2, at New York. Those present were: G. D. Brooke, S. E. Coombs and Jos. O. Osgood. Letters were received from F. L. Nicholson, F. D. Anthony, B. T. Elmore, D. B. Johnston, G. L. Moore, A. S. More, and D. W. Richards.

The call for this meeting, through an oversight, was not sent to E. J. Correll until November 23, and his reply was received on December 2, after the meeting of that day.

The previous report of the Committee is published in Vol. 11, Part 1, pp. 33 to 43, both inclusive, of the Proceedings of the Association of March 15, 16 and 17, 1910. This report, as adopted, contains a revision of the rules previously appearing in the Manual of Recommended Practice and the introduction of additional rules of a similar character.

Under the second instruction of the Board of Direction this Committee last year conferred with Committee V, on Track, and proposed to them that their Rules 1, 2, 3, 4, 5 and 6, under the heading "Inspection of Track," as published in the Manual, be withdrawn, as rules of Rules Committee Nos. 3, 6 and 13, under "Rules Governing Track Foremen," and Nos. 2 and 3, under "Rules Governing Track Supervisors," covered the same ground. This was agreed to by Committee V, but no formal action was taken at the convention. It is, therefore, recommended this year in the conclusions that Rules Nos. 1, 2, 3, 4, 5 and 6, under the heading "Inspection of Track," now published in the Manual, be omitted in future revisions.

In connection with the work of the Committee this year Books of Rules of sixty-one (61) American railroads have been secured and a compilation made showing the subjects covered by them. A few of these rules have been selected and are now presented as an appendix to this report. These rules cover the following subjects:

I. Absence from Duty.
II. Accidents.
III. Ballast—covering the purpose for which ballast is used, material, cross-section, preparation of sub-grade, handling, tamping, surfacing, etc.
IV. Batteries—covering the duties of battery-men and care of batteries.
V. Cars—relative to loading and unloading of roadway material.
VI. Deportment.
VII. Discharging Men.
VIII. Drainage.

It was clearly seen that such rules as I, II, VI and VII could properly form a part of the rules heretofore presented by this Committee, but it was not clear that such rules as those contained under III, IV, V, and VIII should be included. It was, therefore, decided that in order to bring this question before the Association it be recommended that the Committee be instructed to formulate a set of such rules for presentation next year.

CONCLUSIONS.

The Committee presents the following conclusions for your approval:

Under the first of the instructions of the Board of Direction it is recommended that the following additions and revisions be made to the rules passed by the Association for publication in the Manual:

Rule 4, under "General Notice," which now reads:

"4. Employés must exercise the greatest care and watchfulness to prevent injury or damage to persons or property, and in case of doubt take the safe course,"
shall be revised to read:

"4. Employés must exercise care and watchfulness to prevent injury to themselves, other employés and the public, and to prevent damage to property. In case of doubt they must take the safe course. They must know that all tools and appliances are in safe condition before using. They must move away from tracks upon approach and during passage of trains, and, so far as practicable, prevent the public from walking on tracks or otherwise trespassing on the right-of-way."

Under the heading "General Notice," add two (2) additional new rules as follows:

*"10. Employés must not without proper authority absent themselves from duty, exchange duties with others or engage substitutes."

*"11. Employés must conduct themselves properly at all times. They must be civil and courteous to fellow employés and patrons of the road. Employés who are dishonest, vicious, quarrelsome, or use profane, vulgar or immoral language, must be discharged."

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*See amendments, page 62.

Under "Rules Governing Track Foremen, Bridge and Building Foremen and Signal Foremen," Rule 4 in each case, which now reads:

"4. They shall employ men as the........(Title)........directs and see that they properly perform their duties. They must keep the required records of the time of their men and of the materials used,"

shall be revised to read:

"4. They shall employ men as the........(Title)........directs. They must treat employés with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used."

Under "Rules Governing Track Foremen." Rule 5, which now reads:

*"5. They must each have a copy of the current time table and be thoroughly familiar with the Rules and Regulations therein and with the time of trains over their sections. They must carefully observe signals displayed by all trains, and assure themselves before obstructing track that all trains and sections due have passed. No notice will be given of extra trains and employés must protect themselves as prescribed by the rules. Foremen must provide themselves with reliable watches, and, when possible, compare time daily with a standard clock or with conductors' watches,"

shall be revised so that the last clause shall read:

"Foremen must provide themselves with reliable watches, and, when possible, compare time daily with a standard clock or with the watches of other employés who are required to have the standard time."

Under the second instruction of the Board of Direction it is recommended that Rules 1, 2, 3, 4, 5 and 6, under the heading "Inspection of Track," now published on page 66 of the Manual of Recommended Practice, be omitted in future revisions.

Under the third instruction it is recommended that the instructions to next year's Committee provide that rules in the nature of specifications or instructions regarding the conduct of work be prepared, making use of the recommendations of the various Committees dealing with these subjects, and of the best practice of the railroad companies as embodied in their Books of Rules, with a view to providing material which may be of assistance to railroads formulating Maintenance of Way Rules. It is understood that in preparing such rules the Committee will confer with other Committees whose work is affected thereby.

Respectfully submitted,

Jos. O. Osgood, Chief Engineer, Central Railroad of New Jersey, New York, N. Y., *Chairman.*

F. L. Nicholson, Chief Engineer, Norfolk & Southern Railway, Norfolk, Va., *Vice-Chairman.*

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*See amendments, page 62.

F. D. Anthony, Chief Engineer, Quebec, Montreal & Southern Railway, Montreal, Canada.

G. D. Brooke, Division Engineer, Baltimore & Ohio Railroad, Baltimore, Md.

S. E. Coombs, Assistant Engineer, New York Central & Hudson River Railroad, New York, N. Y.

E. J. Correll, Engineer Maintenance of Way, Missouri Pacific Railway, Little Rock, Ark.

B. T. Elmore, Assistant Chief Engineer, Virginian Railway, Norfolk, Va.

A. S. More, Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway, Mt. Carmel, Ill.

G. L. Moore, Engineer Maintenance of Way, Lehigh Valley Railroad, South Bethlehem, Pa.

D. B. Johnston, Division Engineer, Pittsburg Division, Pennsylvania Lines, Louisville, Ky.

D. W. Richards, Signal Engineer, Norfolk & Western Railway, Roanoke, Va. *Committee.*

AMENDMENTS.

Amend Rule 10, under the heading "General Notice," to read as follows:

"10. Employes must not without authority absent themselves from duty, exchange duties with others or engage substitutes."

Amend Rule 11 to read as follows:

"11. Employes will conduct themselves properly at all times, and be courteous to fellow employes and patrons of the road."

Amend Rule 5, under "Rules Governing Track Foremen," to read as follows:

"5. They must have a copy of the current time table and be thoroughly familiar with the rules and regulations therein and with the time of trains over their sections. They must carefully observe signals displayed by all trains, and assure themselves before obstructing track that all trains and sections due have passed. No notice will be given of extra trains, and employes must protect themselves as prescribed by the rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employes who are required to have the standard time."

Appendix A.

EXTRACTS FROM COMPILATION OF BOOKS OF RULES OF SIXTY-ONE (61) AMERICAN RAILROAD COMPANIES AND FROM MANUAL OF RECOMMENDED PRACTICE OF THE ASSOCIATION, 1907 EDITION, WITH SUGGESTIONS FOR NEW RULES.

Note:—Examples of Rules in use by two or more Railroad Companies are first given in each case.

ABSENCE FROM DUTY.

(29 books contain rules on "Absence from Duty.")

Examples of rules in actual use.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., Aug. 1, 1906, page 24.)

"No employe will be allowed to absent himself from duty without special permission from the head of the department in which he is employed, nor will any employe be allowed to engage a substitute to perform his duties."

(Union Pacific R. R., Rules of M. of W. and S., page 19.)

"Employes must not absent themselves from, or exchange duties with, nor substitute others in their place, without proper authority."

PROPOSED RULE.

Employes must not without proper authority absent themselves from duty, exchange duties with others or engage substitutes.

ACCIDENTS—GENERAL.

(Practically all the books contain rules on accidents.)

Examples of rules in actual use.

Determination of Cause:

(Southern Ry., Special Instr. M. of W. Dept., Nov., 1899, page 5.)

"Any material from accidents that would assist in determining the cause of same will be preserved until after the regular investigation is made."

(San Antonio & Aransas Pass Ry., Rules for M. of W. Dept., Aug. 1, 1904, page 53.)

"Such material as broken rails, axles, or other debris, which may be of use in determining the cause of accidents, must be preserved."

(A. R. E. and M. of W. Assn., 1910.)

"Track foremen must, in case of accident, promptly render all assistance in their power, whether the accident occurs on their own or adjacent sections. They shall investigate and report on Form No. ......

all accidents occurring on their sections, which may be attributable to, or result in damage to, track, roadbed or structures."

PROPOSED RULE.

(As above with following addition.)

"and preserve all materials which may assist in determining the cause."

WATCHMEN.

Examples of rules in actual use.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., Aug., 1906, page 81.)

"In case of wreck the Section Foreman must, when necessary, appoint watchmen to prevent freight or company's property from being stolen, and such watchmen must remain on duty until the goods are removed or until they are relieved."

(Louisville & Nashville R. R., Rules for M. of W. employes, 1909, page 44.)

"In case of wreck, the Foreman must at once appoint watchmen to prevent freight or company's property from being stolen. Such watchmen are to remain on duty until relieved."

PROPOSED RULE.

Rule No. 7—Track Foremen—adopted by A. R. E. and M. of W. Assn., 1910, including additions:

Track Foremen must, in case of accident, promptly render all assistance in their power, whether the accident occurs on their own or adjacent sections, *and when necessary appoint watchmen to guard the premises and prevent stealing.* They shall investigate and report on Form No. ...... all accidents occurring on their sections, which may be attributable to, or result in damage to, roadbed or structures, *and preserve all materials which may assist in determining the cause.*

ACCIDENTS TO INDIVIDUALS.

(34 books contain rules on "Examining Tools, etc.")

Examples of rules in actual use.

(Philadelphia & Reading Ry., Rules for M. of W. Dept., May, 1906, page 6.)

"Employes are required to exercise care to avoid injury to themselves or others. They must know that all tools and appliances to be used by them are in safe condition."

(Bess. & L. E. R. R., Rules governing employes, May, 1904, page 8.)

"Each employe is required to look after and be responsible for his own safety as well as to exercise the utmost caution to avoid injury to his fellows, to the public and to property. Employes in every department are warned to see for themselves before using that the machinery or tools which they are expected to use are in proper condition, or see that they are so put before using them."

(20 books contain rules on "Moving Away from Tracks.")

Examples of rules in actual use.

(N., C. & St. L. Ry., Rules governing Operating Dept., page 61.)

"Do not rely upon others to give notice of the approach of an engine or train, or remain near the track while trains are passing, as coal, stone, timber, car doors or other articles are liable to fall from the train. On double track, stand outside and clear of both tracks."

(7 books contain rules on "Employes Walking on Tracks.")

(27 books contain rules on "Public Walking on Tracks.")

Examples of rules in actual use.

(Maine C. R. R., Rules of Operating Dept., October, 1909, page 156.)

"They (Track Foremen) must use every effort to keep trespassers off the right-of-way."

(Seaboard Air Line Railway, Rules for Operating Dept., February, 1910, page 56.)

"All employes are especially cautioned not to walk or stand upon the tracks except when necessary to do so, and, as far as may be possible, to prevent the public from going thereon."

(A. R. E. and M. of W. Assn.)

"Employes must exercise the greatest care and watchfulness to prevent injury or damage to persons or property, and in case of doubt take the safe course."

PROPOSED RULE.

(Above with changes and additions underscored.)

Employes must exercise the greatest care and watchfulness to prevent injury or damage to *themselves, other employés, the public and* to property, and in case of doubt take the safe course. *They must know that all tools and appliances are in safe condition before using, move away from tracks upon approach and during passage of trains, and, so far as practicable, prevent the public from walking on tracks or otherwise trespassing on the right-of-way.*

BALLAST.

(20 books contain rules on "Ballast.")

Examples of rules in actual use.

Purpose.

(Illinois Central Railroad, Rules of M. of W. Dept., 1909, page 7.)

"Ballast is used to distribute the weight of the traffic to the roadbed, to afford rapid and efficient drainage and to secure as uniform support to the track as possible."

(Louisville & Nashville R. R., Rules for M. of W. employes, 1909, page 74.)

"The object of ballast is to secure a solid and uniform bearing for the cross-ties, to distribute the applied load over a large surface, to hold the cross-ties firmly in position, to give elasticity to the track, and to allow the water to pass off freely.

(Pennsylvania Lines West of Pittsburg, August, 1905, Instructions for M. of W. Dept., page 8.)

"Ballast is used to secure a solid bearing for the cross-ties to hold them in position, to secure as uniform support of the track as possible, to distribute the train load over a large surface, to give good drainage, to carry off water during rains, and to prevent as far as possible the freezing of the roadbed."

(Manual of Recommended Practice, 1907 edition, A. R. E. and M. of W. Assn., page 39.)

"Ballast.—Selected material placed on the roadbed for the purpose of holding the track in line and surface."

PROPOSED RULE.

Ballast is used for the purpose of securing a solid bearing for the ties, holding them firmly in position and supporting the tracks as uniformly as possible, distributing the train loads over the roadbed, providing rapid and efficient drainage, and preventing as far as possible the freezing of the roadbed.

Material.

(Louisville & Nashville R. R., Rules for M. of W. employes, 1909, page 74.)

"Broken stone, slag, gravel and cinders are used for ballast."

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 46.)

"Ballast shall be either broken stone, gravel, slag or cinders, and shall in every case be placed as shown on standard plans. The Supervisor of Track shall be responsible for the proper ballast section used."

(Can. N. Ry., M. of W. Rules, August, 1909, page 20.)

"In the selection of ballast, the volume and character of traffic, the climatic conditions and the nature of material in the subgrade should be considered."

PROPOSED RULE.

Ballast shall be of broken stone, gravel, slag, cinders, chats, chert, burnt clay, gumbo or disintegrated granite. The selection of the particular kind of ballast to be used shall be determined by the.........(Title).........

(Manual of Recommended Practice, ed. 1907, A. R. E. and M. of W. Assn., pages 39, 40 and 41.)

Quality and Size—Broken Stone.

(Canadian Pac. Ry., M. of W. Rules, November, 1907, page 22.)

"Broken stone ballast should be uniform in size and composed of rock that will not easily disintegrate."

(Canadian N. Ry., M. of W. Rules, August, 1909, page 20.)

"Broken stone," etc., same as above, except "will not be easily disintegrated."

(Pennsylvania Lines West of Pittsburg, Instructions for M. of W. Dept., Aug. 1, 1905, page 8.)

"When stone is used it must be broken uniformly, not larger than a cube that will pass through a 2½-in. ring in any direction nor smaller than will be caught on a ¾-in. screen. It must be screened free from all dust, rubbish and particles under ¾ in. in diameter. Slabs over 3 in. in length that pass through a 2½-in. ring must be broken by hand."

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., Aug. 1, 1906, page 46.)

"Broken stone ballast shall be made from hard, tough, durable trap or limestone rock, or other suitable stone, crushed so as to pass through a two (2) inch ring in any direction unless otherwise specified; screened in revolving screens and free from dust, rubbish, dirt and particles under three-fourths (¾) inch in diameter.

"Stone must be crushed in suitable crushers that will break stone with a clean, sharp cleavage. If broken by hand, stone shall be broken in clean places especially selected for the purpose."

(Louisville & Nashville R. R., Rules for M. of W. employes, 1909, page 74.)

"Stone ballast shall be broken into pieces that will pass through a ring 2½ in. in diameter, but which will be caught on a screen having 1-in. openings. All ballast should be free from dust, earth and trash."

PROPOSED RULE.

Broken stone ballast shall be clean, free from earth and all foreign substances, of the quality and sizes required under the Company's specifitions for stone ballast.

(Specifications given in Manual of Recommended Practice, 1907 ed., A. R. E. and M. of W. Assn., page 40.)

Quality, etc., of Gravel.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., Aug. 1, 1906, page 47.)

"Gravel ballast must be free from loam and stone which will disintegrate."

(Canadian Pacific Ry., M. of W. Rules, November, 1907, page 22, and Canadian N. Ry., M. of W. Rules, August, 1909, page 20.)

"The gravel ballast will be used ordinarily; it should be clean, not too coarse, and of uniform size and character; it should be free from fine sand, loam and clay, which will make dusty track, cause weeds to grow and interfere with drainage. It should not contain large stones, for they will cause rough riding track."

(Manual of Recommended Practice, 1907 ed., A. R. E. and M. of W. Assn., page 40.)

"Gravel should be screened or washed where prevention of dust is an object, but this need not be done where the character of traffic is such that dust is not particularly objectionable. It is recommended that gravel be screened or washed where the proportion of sand or clay exceeds 50 per cent. The minimum size should be such as is retained on screens of 12 meshes per inch. By this is meant the size pebble that would be retained in a thorough, careful test."

PROPOSED RULE.

Gravel ballast shall be of a uniform size, clean and free from fine sand, loam, clay and stones which will disintegrate or cause rough riding track.

Quality, etc., of Cinders.

(Manual of Recommended Practice, 1907 ed., A. R. E. and M. of W. Assn., pages 40 and 41.)

"The use of cinders as ballast is recommended for the following situations: On branch lines with a light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; in cuts and on fills; as sub-ballast on new work where dumps are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn."

(Manual of Recommended Practice, 1907 ed., A. R. E. and M. of W. Assn., page 41.)

Quality, etc., of Burnt Clay.

"The material should be black gumbo or other suitable clay free from sand or silt. The suitability of the material should be determined by thorough testing in a small test kiln before establishing a ballast kiln.

"The material should be burned hard and thoroughly.

"The fuel used should be fresh and clean enough to burn with a clean fire. It is important that a sufficient supply be kept on hand to prevent interruption of the process of burning.

"Burning should be done under the supervision of an experienced and competent burner.

"Ballast should be allowed to cool before it is loaded out of the pit.

"Absorption of water should not exceed 15 per cent. by weight."

Sections.

(Canadian N. Ry., M. of W. Rules, August, 1909, page 21.)

"The Roadmaster will insure that the proposed standard ballast section is used for the different classes of ballast."

(Union Pacific Ry., Rules for M. of W. and S., April, 1909, page 43.)

"The section of ballast will conform to standard plans or with special instructions."

Depth of Ballast.

(Louisville & Nashville R. R., Rules for M. of W. employes, 1909, page 74.)

"The standard depth of ballast shall be 1 ft. beneath the center of the tie. The ballast shall be flush with the top of the tie for its whole length, and shall slope down from the ends of the ties at the natural slope of the material."

(Canadian Northern Railway, M. of W. Rules, August, 1909, page 21.)

"The depth of ballast under the ties for main line and important branches must be not less than 8 in., and for minor branches it shall not be less than 6 in."

(Pennsylvania Lines West of Pittsburg, Instructions for M. of W. Dept., August, 1905, page 8.)

"The depth and slope of the ballast must conform to the standard drawing."

PROPOSED RULE.

The depth and slope of the ballast shall conform to the standard section for the particular kind of ballast to be used.

Preparation of Subgrade.

(Illinois Central R. R., Rules for M. of W. Dept.. 1909, page 7.)

"Before distributing ballast the subgrade must be properly prepared and banks widened so as to secure drainage and retain the ballast.

"The standard diagram should govern in preparing the subgrade for ballast. Stakes should be set for line and surface."

(Pennsylvania Lines West of Pittsburg, Instructions for M. of W. Dept., Aug. 1, 1905.)

"Before distributing ballast the subgrade must be properly prepared and the banks widened so that the ballast will not roll down the banks or be washed away. The edges of cuts must be carefully shaped to the proper section and always below the bottom of the old ballast, so as to give the proper drainage."

(Canadian Northern Ry., M. of W. Rules, August, 1909, page 20.)

"Preparatory to ballasting track, centers and grade line should be given by the engineer. All unsuitable material above the bottom of the ties must be removed and used to widen narrow embankments, according to the standard roadbed section. Track should be thrown to line, then ballast may be delivered in the middle or on the side of the track, or both."

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 47.)

"Before distributing ballast the subgrade must be properly prepared and the banks widened so that the ballast will not be wasted or washed away. Cuts will also have the edges carefully shaped to the proper section and always below the bottom of the old ballast, so as to give proper drainage.

"Before ballasting track, line and grade stakes shall be set by the engineer. All unsuitable material shall be removed down to the bottom of the ties and used to widen narrow embankments, or otherwise, as the engineer may direct. Track should be then thrown to line and ballast delivered."

(Union Pacific Ry., Rules for M. of W. and S., April, 199, page 45.)

"Before distributing ballast the roadbed must be properly prepared with embankments and cuts widened to conform to standard plan. The section of ballast will conform to standard plans or with special instructions. The toe line of ballast must be kept at all times neatly lined."

PROPOSED RULE.

Track centers and grade lines shall be given by the engineer previous to ballasting track. The subgrade shall be properly prepared for ballast; all unsuitable material above the bottom of the ties removed, and banks widened to retain the ballast and secure good drainage. The track shall then be thrown to line and the ballast delivered.

Open Track, etc.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 48.)

"When ballasting, open track shall be reduced to a minimum and such track carefully watched, loosening bolts, if necessary, to avoid rail buckling and throwing track out of line."

(Burlington Route, Rules of Track, Bridge and Building Depts., January, 1902, page 34.)

"When resurfacing or raising track, leave it in good line and surface for the passage of all trains at the usual rate of speed, special attention being given to make the run-offs long enough and keep sufficient material between the ties to prevent the track from going out of line."

PROPOSED RULE.

Track shall be kept in good line and surface when ballasting, and shall be carefully watched to avoid rail buckling and throwing track out of line.

Handling.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., Aug. 1, 1906, page 46.)

"Broken stone ballast should be handled with forks and not with shovels."

(Union Pacific R. R., Rules for M. of W. and S., April 1, 1909, page 45.)

"Care must be taken in handling ballast to keep it clean and free from earth. Banks should not be built up against the toe of ballast so as to prevent drainage."

(Illinois Central R. R., Rules of M. of W. Dept., 1909, pages 7 and 8.)

"Rock ballast or slag distributed along the track for use must be handled into the track exclusively with ballast forks of approved type.

"The use of shovels for this purpose allows dirt to become mixed with the ballast, which prevents proper drainage, causes churning track and encourages vegetation.

"Gravel ballast should be clean, free from loam or earth, and must be carefully handled to prevent mixing with it the earth of the roadbed."

Mixing Ballast with Old Material.

(Canadian Northern Ry., M. of W. Rules, August, 1909, page 20.)

"The practice of mixing new ballast with old, unsuitable material which was between and around the ends of ties is prohibited."

Wasting.

(Union Pacific R. R., Rules for M. of W. and S., April 1, 1909, page 45.)

"Care must be taken in unloading and distributing ballast to avoid wasting the material on the slopes of embankments."

(Canadian Pacific Ry., M. of W. Rules, November, 1907, page 23, and Canadian Northern Ry., M. of W. Rules, page 20.)

"Avoid wasting ballast down the sides of embankments. Material for raising and ballasting must not be taken from the slopes of the embankment to the reduction of the same below standard."

(Louisville & Nashville R. R., Rules for M. of W. employes, 1909, page 74.)

"Care must be taken not to waste ballast by allowing it either to roll down banks or to become mixed with dirt. Forks, and not shovels, must be used to handle rock ballast into the track."

PROPOSED RULE.

Care shall be taken in handling ballast to prevent mixing with earth, or with old, unsuitable material between and around the ends of ties, or wasting down the slopes of embankments. Ballast forks should be used exclusively for handling broken stone and slag ballast.

Embankments Not Well Settled.

(Pennsylvania Lines West of Pittsburg, Instructions for Government of M. of W. Dept., August, 1905, page 8.)

"On embankments that are not well settled the surface of the roadbed shall be brought up with cinder, gravel or other suitable material."

PROPOSED RULE.

On embankments that are not well settled the surface of the roadbed shall be raised with suitable material. Material for this purpose shall not be taken from the slopes of the embankments.

Tamping.

(Illinois Central R. R., Rules of M. of W. Dept., pages 7 and 8.)

"Rock and slag ballast must always be tamped with tamping picks, except where it is being renewed in such quantities as to require more than one raise, in which case shovel tamping will be permitted for the first raise only.

"Gravel ballast must be tamped with tamping picks or tamping bars, except when ballast renewal requires more than one raise, in which case shovel tamping will be permitted for the first raise.

"The most thorough tamping must be done directly under and about 15 in. on each side of the rails. Shovels must not be used for tamping when picking up low joints or smoothing track in any kind of ballast.

"The shoulder ballast must be picked down to subgrade when necessary, cleaned and thrown back."

(Burlington Route, Rules of Track, Bridge and Building Depts., page 33.)

"Rock ballast must always be broken outside of the track and thrown in with forks. Shovels should never be used for handling broken stone.

The greatest care should be taken to keep all ballast clean and free from dirt. The shoulder ballast should be picked down to the bottom when necessary, and when clean thrown back with forks."

(Union Pacific Ry., Rules for M. of W. and S., April, 1909, page 46.)

"On new track, tamp the entire length of ties; special care should be taken to insure thorough tamping from end of ties to one foot inside of the rail. On old track the center should be filled and lightly tamped."

(Manual of Recommended Practice, 1907 ed., A. R. E. and M. of W. Assn., pages 62, 63 and 64.)

"Proper methods of tamping" recommended.

PROPOSED RULE.

Ballast shall be well and thoroughly tamped at each end of the ties, directly under and about fifteen inches (15″) on each side of the rails. The center shall be filled and lightly tamped.

Tamping picks shall be used for tamping broken stone and slag ballast.

Bonded Rails.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 48.)

"Where rails are bonded, any ballast, mud or dirt that may touch the rails should be removed to allow a clear space of at least one inch between such material and base of rail. At road crossings, platforms, etc., where it is not possible to keep the rails clear, the mud or dirt shall be removed and clean gravel or rock ballast substituted."

PROPOSED RULE.

Ballast shall not be allowed to come in contact with rails where bonded At points where it is impossible to prevent such contact, broken stone or clean gravel ballast shall be used.

Surfacing.

(Burlington Route, Rules of Track, Bridge and Building Depts., January, 1902, page 33.)

"When resurfacing track on ballast, foremen must not raise the general surface of the track, but merely raise the low places."

(Union Pacific Ry., Rules for M. of W. and S., April, 1909, page 46.)

"Never change the general surface of track in tunnels, under overhead structures, or in front of platforms, chutes, water tanks or standpipes without grade stakes."

(Illinois Central R. R., Rules of M. of W. Dept., 1909, page 8.)

"Foremen must not raise the general surface of the track in tunnels."

PROPOSED RULE.

The general surface of track must not be raised without proper authority.

Trimming, etc.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 47.)

"When ballasting is completed, it must be neatly trimmed to standard section, and the track must be put to perfect gage, surfaced and lined to the stakes furnished by the Engineer."

PROPOSED RULE.

After ballast is placed it shall be neatly trimmed, track accurately gaged and properly surfaced and lined to conform to the standard drawing.

Filling Between Tracks.

(Pennsylvania Lines West of Pittsburg, Instructions for Government of M. of W. Dept., August, 1905, page 8.)

"In filling up between tracks, coarse, large stones must be placed at the bottom in order to provide for drainage, but care must be taken to keep the coarse stone away from the ends of the ties.

(Southern Ry., Special Instructions M. of W. Dept., January, 1902, page 12.)

"On double track the space between tracks may be filled with rough ballast, but it must not come above the bottom of the ties and then be leveled up even with the ties with standard ballast."

PROPOSED RULE.

The space between double tracks up to the underside of the ties shall be filled with coarse stones and then be leveled off with standard ballast up to the tops of ties.

Heaving, etc.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 47.)

"Where heaving or wet spots develop, the bad material must be taken out to such a depth and in such a manner as to insure drainage and the space filled with good porous material."

(Canadian Northern Ry., M. of W. Rules, August, 1909, page 21.)

"Where there is heaving or wet spots, the wet material must be taken out to such a depth and in such a manner as to insure drainage and the space be filled with cinders, gravel or other good material."

PROPOSED RULE.

When track becomes foul, churns, heaves, or wet spots develop, the bad material shall be removed to the depth and in the manner required to secure drainage and the space filled up with good material.

BATTERIES.

See under "Batterymen."

BATTERYMEN.

(6 books contain rules on "Batterymen.")

Examples of rules in actual use.

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"Batterymen report to and receive instructions from the Repairmen."

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, page 26.)

"Batterymen report to and receive their instructions from the Electricians."

(Philadelphia & Reading Ry., Rules for M. of W. Dept., May, 1906, page 41.)

"Report to Automatic Signal Maintainers."

(C. R. R. of N. J., Rules for M. of W. and Signal Depts., March, 1903, Page 22.)

"They report to and receive orders from Foreman of Signal Maintainers and will recognize the authority of the Maintainers in their sections, rendering them such assistance as may be requested."

PROPOSED RULE.

Batterymen shall report to, and receive instructions from, the..........
(Title)
....

Responsibility.

(C. R. R. of N. J., Rules for M. of W. and S. Depts., March, 1903, page 34.)

"They are responsible for the maintenance and proper working of batteries on their sections."

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"They are responsible for the proper condition of all batteries and connections under their charge."

PROPOSED RULE.

They shall be responsible for the proper inspection and safe condition of all batteries and connections under their charge.

Batteries (Inspection).

(Phila. & R. Ry., Rules for M. of W. Dept., May, 1906, page 41.)

"They must inspect batteries at least once each week and make renewals at regular intervals that constant voltage may be maintained."

(Union Pacific R. R., Rules of M. of W. and Str., April, 1909, page 67.)

"Inspect all batteries at least once a week, and make renewals at least once a month."

(Norfolk & Western Ry., Rules of Signal Dept., June, 1907, page 21.)

"Where primary batteries are used they will inspect all batteries at least once a week and will make renewals one week before cells will probably be exhausted, as they may be delayed unavoidably at times and no chances of failures must be taken."

PROPOSED RULE.

They must inspect all batteries in their districts at least once each week and make renewals as frequently as necessary to maintain constant voltage.

Records.

(L. I. R. R., Rules of Signal Dept., 1904, page 22.)

"They shall keep a detail record of the performance of every battery, the material used, the dates when cleaned or renewed and the time spent on them."

PROPOSED RULE.

They must keep detailed records of the performance of batteries, and of the materials used.

Relieving Others.

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, page 26.)

"Batterymen must act as relief men for Electricians, as they may be assigned, and must post themselves fully on the Electrician's work."

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"Batterymen shall act as relief men for Repairmen, as they may be assigned, and shall post themselves fully on the Repairmen's work."

(Phila. & R. Ry., Rules for M. of W. Dept., May, 1906, page 41.)

"They must assist the Maintainers in cases of emergency when called upon, and at other times, when such action will not interfere with the proper care of batteries."

PROPOSED RULE.

They must, in case of emergency, render all assistance in their power to the .... (Title) .... and at other times, when not interfering with their regular duties.

Maintenance of Batteries.

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, page 27.)

"In the maintenance of batteries, they must follow closely the special instructions issued by the Signal Supervisor."

(Norfolk & W. Ry., Rules of Signal Dept., June, 1907, page 23.)

"They will follow standard directions furnished by the different manufacturers for care of batteries."

PROPOSED RULE.

They shall follow the special instructions, and the directions furnished by the different manufacturers, for maintaining batteries.

Care, etc., of Materials.

(C. R. R. of N. J., Rules for M. of W. and Signal Depts., March, 1903, Page 34.)

"They will keep the foreman advised as to material required."

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"They are responsible for the proper care and use of the material furnished them."

Care, etc., of Tools.

(Norfolk & W. Ry., Rules of Signal Dept., June, 1907.)

"They will be responsible for tools furnished them, and will replace any which may be lost."

PROPOSED RULE.

Rule No. 9, Signal Foremen, adopted 1910, A. R. E. and M. of W. Assn.

"They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties and shall make requisition to the .... (Title) .... from time to time, as additional supply becomes necessary."

Changes.

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, page 26.)

"They must not make any changes in wiring or connections without instructions in writing from the Electrician."

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"They must not make any changes in wiring or connections without instructions in writing from the Repairmen."

PROPOSED RULE.

Rule No. 11, Signal Foremen, adopted 1910, with change.

"They must not make nor permit any permanent rearrangement or change in wiring or connections without proper authority."

Battery Wells, Etc.

(L. I. R. R, Rules of Signal Dept, 1904, page 21.)

"They shall keep all battery wells and lockers clean and shall keep them locked. No refuse material shall be left around the batteries."

(Norfolk & W. Ry., Rules of Signal Dept., June, 1907, page 22.)

"They will keep their battery houses, closets and cases neat and clean."

(P. & R. Ry., Rules for M. of W. Dept., May, 1906, page 41.)

"They must keep battery houses, chutes and surroundings clean."

PROPOSED RULE.

They shall keep all battery wells, chutes, boxes, cupboards and houses neat and clean, and locked when not in use.

Care of Batteries (Protection).

(Long Island R. R., Rules of Signal Dept., 1904, page 21.)

"They shall see that batteries are kept at an even temperature, protected from extreme heat or cold."

(N. Y., N. H. & H. R. R., Rules of Signal Dept., August, 1908, page 21.)

"Batteries must be kept at an even temperature as nearly as possible and protected from extreme heat and cold."

PROPOSED RULE.

They shall keep batteries at as even a temperature as possible and protected from extreme heat or cold.

Renewing Batteries.

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, page 26.)

"When renewing track battery, one or a sufficient number of cells must be kept in service to work relay at all times."

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"In renewing track battery, the Batteryman must never have more than one cell out of service at one time."

(Norfolk & Western Ry., Rules of Signal Dept., June, 1907, page 23.)

"They will, when cleaning track battery, except where Storage Battery is used, never have more than one cell out of service, and two cells of any one track battery must not be renewed on the same day. Whenever possible, one cell must be in service at least a week before another is renewed.

"They will not take more than two cells out of service in any one main or signal battery at a time, and will not renew an entire battery unless absolutely necessary, but will arrange their work to keep the greater part of a battery always in service.

"They will, when renewing track cells, always leave the battery connector on positive leg and not on the battery, thus preventing any possibility of connecting up with wrong polarity."

PROPOSED RULE.

They must not keep more than one cell out of service at one time when renewing track batteries, or more than two cells when renewing main or signal batteries.

Batteries—Jars.

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"They shall see that the jars are kept clean and bright and free from salts."

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June 1, 1908, page 26.)

"The jars must be kept clean and bright and free from creeping salts."

(Phila. & R. Ry., Rules for M. of W. Dept., May, 1906, page 41.)

"They must not allow broken jars to remain in service."

(Norfolk & W. Ry., June, 1907, pp. 21 and 22.)

"They must handle jars with great care, to prevent breaking, and in moving same or adding water, must not disturb the solution or elements."

"They must take cracked or broken jars out of service at once, and remove all spilled solution carefully."

"They will not leave elements in service which have poor or unsafe connections."

PROPOSED RULE.

They shall handle jars with care to prevent breaking or disturbing the elements, and keep them clean, bright and free from creeping salts. All cracked or broken jars shall be taken out of service immediately.

Battery Solution.

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, page 27.)

"They must not empty battery solution or throw such refuse in streams, or on the roadbed, ties, bridges, or places where the solution may come in contact with wires on the top of or buried in the ground."

PROPOSED RULE.

They must not empty battery solution in streams, on roadbed, ties, bridges, or where the solution may come in contact with wires on top of or under the ground.

Batteries (Jumpers).

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, Page 26.)

"Jumpers must be used when removing cells, in order not to open a normally closed circuit. When track and other batteries are connected in multiple, jumpers are not required."

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"Jumpers will be provided for cutting out cells, and care must be used never to open a normally closed circuit in removing cells."

(Norfolk & Western Ry., Rules of Signal Dept., June, 1908, page 22.)

"They will use extreme care never to open a normally closed circuit when removing cells, but will put jumpers on before taking them out, except in case of storage batteries and track batteries connected in multiple. A convenient jumper can be made of two pencil zincs connected by insulated wire."

PROPOSED RULE.

They shall use jumpers when removing cells to prevent opening normally closed circuits, except where batteries are connected in multiple.

Scrap.

(N. Y. C. & H. R. R. R., Rules of Signal Dept., June, 1908, page 26.)

"They must collect at headquarters all scrap zinc and other material and send same to the Storekeeper the first of each month with report, giving weight of each kind of material shipped. Material that is of value must not be thrown away."

(L. I. R. R., Rules of Signal Dept., 1904, page 21.)

"They shall collect all old scrap zincs and copper taken from batteries, at headquarters, and send it to the Storekeeper the first of each month. Nothing that has any value shall be thrown away."

(Norfolk & W. Ry., Rules of Signal Dept., June, 1907, page 23.)

"They will turn into scrap, broken or partly used zincs, unfit for service, and lay aside for Inspector any material defective through fault of the manufacturer."

"They will collect all scrap zinc, copper and copper deposit at their headquarters as soon as it is recovered, and keep it locked up until it is called for by the Maintainer, and will assist the latter in shipping same."

PROPOSED RULE.

They shall collect all old scrap zinc, copper and other materials and ship to Storekeeper once each month.

Batteries (Gravity).

(Union P. R. R., Rules and Regulations for M. of W. and Str., April, 1909, pp. 68 and 69.)

"Pour out carefully and save old, clear solution, and scour jar. Pick out copper deposit and save it, wash the copper, clean the zinc, and place the copper in the bottom of the jar, being sure that the insulation is perfect on the connecting wire, that wire is properly connected to copper, that the latter has the proper number of leaves, and that the bottom is securely fastened to them; then wash out old vitriol and put good crystals back in jar, add new vitriol leveled off to one-eighth (1/8 in.) inch below the top of the copper, then put in zinc with bottom two and one-half (2½ in.) inches above top of copper, add clean water to bottom of zinc; add enough clear solution saved from old cell to cover zinc one-half inch (½ in.). Thoroughly clean all connections, and put in service. Zincs more than two-thirds consumed must not be placed in service."

(L. I. R. R., Rules of Signal Dept., 1904, pp. 22, 23 and 24.)

"The following rules will be observed in the maintenance of gravity batteries:

"A.—All gravity zincs must be cleaned 10 days after the cell has been set up, and every three weeks thereafter.

"B.—A zinc that is more than half consumed must not be used on track battery. When it is half consumed it must be transferred to one of the main battery cells.

"C.—The zincs in all main block batteries are to be used, whenever practicable, until consumed to one-quarter their original weight.

"D.—All battery connections must be inspected at each visit, and no elements with poor or unsafe connections shall be left in the circuit.

"E.—If stalactites form on the zincs they must not be scraped off and allowed to drop in the cell. The zincs must be removed and cleaned.

"F.—Gravity batteries give the best results with the bottom of the zinc at a distance of two and one-half inches above the top of copper. Adjustable zincs shall be kept as nearly as possible at that distance. The bottom of the zinc should never be less than two inches or more than three and one-half inches from the top of the copper.

"G.—Before placing copper element in cell examine it carefully and see that the parts are properly riveted together and that the copper connecting wire is properly attached to one of the leaves.

"H.—Copper connecting wires with defective or improper insulation must not be used.

"I.—Copper elements that have not a full number of leaves or that present less than two-thirds of the original surface must not be left in the circuit.

"J.—In order to prevent creeping of salt, copper connecting wires must stand away from side of the jar and must not be bent over the edge.

"K.—In renewing cells, all blue vitriol that remains in the cell must be carefully cleaned and used.

"L.—All cells are to be charged with 3 lbs. of blue vitriol crystals—dust must not be used.

"M.—In renewing a cell, save about one pint of the old zinc sulphate solution, and after the elements and the blue vitriol and water have been placed in the jar, pour the old solution gently on top of the zinc and add a sufficient amount of water to bring the top of the solution to within one inch of the top of the jar.

"N.—If it becomes necessary to move a cell or add water, great care must be taken not to disturb the line of demarcation between the two solutions.

"O.—After a cell has been set up, blue vitriol must not be added until the cell is again renewed.

"P.—The object is to get as long life as possible from the battery, but to avoid any possibility of its becoming too weak to do the work required.

"Q.—If a jar cracks, it must be promptly cut out and removed from the circuit.

"R.—Zinc sulphate solution must never register less than 15 degrees or more than 30 degrees. If the density of the zinc solution becomes too great, a portion must be drawn out and clear water added.

"S.—In renewing cells the loose copper in the jars must be carefully saved and, together with scrap zinc or any defective new zinc, must be taken to headquarters.

"T.—Blue vitriol deteriorates very rapidly when exposed to heat or the action of the atmosphere."

Recharging Storage Batteries.

(Union Pacific R. R., Rules for M. of W. and Str., April, 1909, pp. 71-75.)

"In charges subsequent to the initial charge, the general rule is that the amount of current put into the cell should be twice the amount delivered by the cell during the thirty or less days elapsing since the next previous charge. Under normal conditions and service with style "b" signals, the amount of current required of a cell will vary from 45 to 75 ampere-hours per month; and the amount of current the cell should receive on recharge will correspondingly vary between 80 and 150 ampere-hours. In this connection it should be borne in mind that while the type S-7 cell has a capacity of only 51 ampere-hours at its normal discharge rate, the capacity developed through a discharge extending over a period of thirty days may be as high as 100 ampere-hours.

"On account of the nature of the service, however, it cannot be known definitely just what amount of current has been delivered from the battery during the month, and it becomes necessary to determine just how many hours the battery shall be charged entirely from voltage and specific gravity readings taken during the progress of the charge.

"Just before the cell is placed on charge the voltage and specific gravity should be taken and recorded, and during the progress of the charge similar readings recorded, taken at intervals of about three hours. It will be found that both voltage and specific gravity will gradually rise until a point is reached where charging for two or three hours fails to raise either. Then, and not until then, is the cell fully charged. The maximum voltage at this time will vary for cells of different ages, although constant for any particular cell over a period of several months, but the specific gravity of the electrolyte at this point should always be adjusted, if below 1.270, to 1.300 for cells of all ages. It will be found that if cells have not received good care in the past and acid has been added unnecessarily, that the specific gravity will continue to rise greatly above 1.300. This indicates excessive sulphation of the plates, and in such cases the electrolyte should be successively reduced by dilution with pure water, the charge continuing uninterruptedly, until the cell no longer exhibits a tendency to exceed that point. It rarely occurs that a cell will fail to rise to 1.270, but in such an event and the cell fails to show any rise during a period of six hours' charging, it should be taken off charge and discharged at about 10 amperes to a voltage of 1.5 volts. The electrolyte, which will then register probably about 1.150 or less, should be replaced with new electrolyte of 1.170 specific gravity and the cell recharged. The usual source of such trouble is in the electrolyte having been spilled from the cell while out on the road and replaced with water. Replacement for ordinary evaporation should be made with pure water only, but in replacement for acid spilled, of course a certain amount of electrolyte must be used."

"Each month, as the cells are returned to the charging station, they should be superficially examined for damaged parts, and the outside of wood cases and tops of rubber jars thoroughly washed. The terminals should receive special attention and all corrosion thoroughly cleaned off and a wipe of vaseline applied. All connectors should be taken apart and rinsed well in bi-carbonate of soda, then in water, and finally, when dry, dipped in some light mineral oil. It is important that corrosion be not allowed to accumulate on terminals and connections where it is almost certain to find its way into the cell.

"SPECIAL TREATMENT."

"Once in six months each cell should be taken apart and closely examined for damaged or defective parts. The sediment should be cleaned from bottom of jar and the plates lightly washed before being replaced. The same electrolyte may be used again. The principal object of this examination is to discover any cell which should be discarded as too old or too much worn to continue in service for another six months, the determination in this case being based principally upon the mechanical condition of the plates with regard to the amount of active negative that has been lost out of them. Some system of record should be adopted to insure that all cells receive the examination.

"Once each year the cell, after being charged in the ordinary manner, should be discharged at a rate of 10 amperes to 1.5 volts and a record kept of the ampere-hour capacity of the cell as thus developed. The old electrolyte at this time also should be thrown away and immediately replaced with new electrolyte of the same specific gravity. This is done in order to discard all impurities held in solution in the electrolyte, as it has been found that after a year's work in this service the electrolyte is almost certain to contain a greater or less amount of such impurity. This discharge and subsequent charge are important in more ways than one, and should not be neglected, in that they give a reliable estimate of the value and condition of the cell. Sometimes a cell which has become so badly sulphated as to appear worthless, and one which no amount of continuous charging seems to affect in the least favorably, will be again brought up to first-class condition merely by charging and discharging a few times. If a cell fails to register 40 ampere-hours or more on the first discharge, it should be charged and discharged a second time, and if necessary this process repeated until the requisite capacity is developed or the cell discarded as worthless. If the cell registers 40 or more ampere-hours' capacity on the first discharge, a subsequent charge of 25 or 30 hours at five amperes will place it in condition for service.

"Cells temporarily out of service should be kept in a fully charged condition by being given a freshening charge of 4 or 5 hours' duration twice per month. If it is not convenient to give them this freshening charge, they should be placed entirely out of commission in the following manner: First, give them a full charge, then remove the plates from the electrolyte and place the negatives and positives separately in water for about one hour to remove all acid. After draining and drying, the positives are ready to store away. If the negatives in drying become hot enough to steam, they should be rinsed or sprinkled with water a second time. When dry, completely immerse the negatives and allow them to stand for three or four hours in electrolyte of about 1.210 specific gravity. After washing and drying as before, they are ready to be stored away. Rubber separators should be rinsed in water and saved, but the wood separators are not worth saving unless comparatively new and in good condition. If saved, they should be kept immersed in water or weak electrolyte. In putting such cells into commission again, treat them as entirely new cells, being governed by the rules relating to placing new cells into commission."

(Twenty books contain rules on "Cars," divided between "Loading," "Moving," "Riding on," "Use of," etc. "Loading" is taken as an example.)

(Four books contain rules on "Loading, etc., of Cars.")

Examples of rules in actual use:

CARS, LOADING, ETC.

(Union Pacific R. R., Rules for M. of W. and Str., April, 1909, page 25.)

"Material received on cars must be promptly unloaded. In loading cars, care must be taken not to exceed their capacity. Piles, timber and structural material must be loaded in such a manner as to insure safe passage through bridges and tunnels. Foremen must be conversant with the Master Car Builders' Rules governing loading, and comply therewith. Rails, stone or other heavy material must be distributed on the cars uniformly."

(Penna. Lines W. of P., Instr. for M. of W. Dept., August, 1905, page 30.)

"All cars should be loaded and unloaded as promptly as possible and disposition given agents for prompt movement of the same, etc.

"Side-dump, hopper and other similar cars should have the doors closed as soon as they are unloaded.

"Cars which have been stored, and the floors of which are so dirty as to cause the growth of grass or weeds, should be thoroughly cleaned to prevent rotting of the floors.

"Drop-bottom cars used for gravel, cinders, etc., should have the pockets properly cleaned out when the cars are unloaded."

(Canadian P. Ry., M. of W. Rules, November, 1907, page 9.)

"Cars must not be placed on the main track to be loaded or unloaded unless authorized by a train order."

(L. S. & M. S. Ry., Rules of Engr. Dept., April, 1907, pp. 42-44.)

"In unloading ties or other bulky material it must never be left between tracks.

"In loading ties on flat cars, for shipment by freight train to points on or beyond the Roadmaster's division, they must be loaded lengthwise of the car, and on the floor of the car a tie must be laid crosswise at each end, under outside ends of end tiers, to prevent shifting. Sufficient stakes, of the necessary length and strength, must be used on the sides of the car.

"When ties are to be loaded on flat cars, and a work train is to distribute them, the cars should be staked properly at the end, and the ties may be loaded crosswise for convenience, but cars so loaded must never be shipped in regular trains. In loading cars in this way care must be taken to clean off any ice or snow, and, if necessary, the cars should be salted. In the loading, the ties must be piled so that the end of no tie will project beyond the body of the car. When handling cars in this way, the train conductor and foreman in charge must see that the ties are watched, to guard against the possibility of any of them falling off while the train is in motion.

"In loading ties on gondolas, they must be loaded lengthwise of the car, and if it is desired to pile them higher than the sides of the car, suitable stakes must be used.

"In loading rails, if flat cars are used, care must be taken that the ends are protected by planks, properly braced, to prevent the rails from sliding or projecting over the end of the car.

"Care must be taken not to load cars beyond their capacity.

"When loading lumber, long timber, telegraph poles, masts, piles, structural material, rails, etc., Foremen must act in accordance with the rules prescribed by the General Superintendent, from time to time, which rules may be obtained from the Station Agent. When freight is loaded on open cars, it must be loaded in such a manner as will insure its safe passage through all bridges or tunnels. When shipping steam shovels, derricks, dirt levelers and other Engineering Department equipment, great care must be exercised to make sure that all parts are properly secured and will clear all obstructions.

"Small amounts of freight to be shipped must be taken to the nearest station and regularly billed, so that the Agent may load other material with it to make full carload lots.

"All concerned must see that cars are loaded or unloaded and forwarded promptly and that proper billing is furnished for all cars or freight. All scrap, pieces of ties, bark, gravel, cinders, rubbish, etc., must be cleaned off before such cars are turned over to the Transportation Department."

PROPOSED RULE.

They (Track Foremen) shall be responsible for the prompt loading, unloading and forwarding of cars containing roadway material. They shall conform to the Master Car Builders' rules governing the loading of material on cars.

Deportment.

(Seventeen books contain rules on "Deportment.")

Examples of rules in actual use:

(El Paso & Southwestern, Rules for M. of W. Dept., April, 1906, page 5.)

"Civil deportment and proper conduct on the part of all, especially those having control of men, is required. Employes on duty must neither use abusive, boisterous, profane or vulgar language, nor enter into altercations with any person, no matter what provocation may have been given, but will make note of the facts and report them to their immediate superior."

(Louisville & Nashville R. R., Rules for M. of W. Employes, 1909, page 7.)

"No person who is vicious, profane or uncivil in deportment shall be employed or continued in the service."

(Pere Marquette R. R., Rules for Operating Dept., December, 1903, pp. 53 and 58.)

"Boisterous, profane or vulgar language by employes on or about the premises of the company, is strictly forbidden, and will be considered just cause for dismissal. Civil, gentlemanly and quiet deportment toward fellow-employes, as well as patrons of the road, is required of all employes."

"Employes who are dishonest, immoral, vicious, quarrelsome or uncivil in deportment will not be retained in the service."

PROPOSED RULE

Employes must conduct themselves properly at all times. They must be civil and courteous to fellow-employes and patrons of the road. Employes who are dishonest, vicious, quarrelsome or use profane, vulgar or immoral language will be discharged.

Discharging Men.

(Twenty-eight books contain rules on "Discharging Men," divided between "Cause," "Changes," "Reporting" and "Time Checks." The following are taken as examples:)

Two books contain rules on "Discharging Men Without Cause." Eight books contain rules on "Discharging Men for Neglect of Duty.")

Examples of rules in actual use:

(El Paso & Southwestern, Rules for M. of W. Dept., April, 1906, page 4.)

"Foremen must not excuse neglect of duty, but must dismiss or suspend from duty, or, in case of personal record employes, report for dismissal or suspension unfaithful employes. No employe must be discharged without cause, and never for the purpose of making room for another. The average allotment of men must not be exceeded without proper authority."

(Louisville & Nashville R. R., Rules for M. of W. Employes, 1909, page 32.)

"Foremen must not discharge any man without good cause, and must discharge any whom they find to be dishonest, negligent or who wilfully damages or destroys any part of the Railroad Company's property."

(Illinois Central R. R., Rules of M. of W. Dept., 1909, page 49.)

"Foremen are not at liberty to excuse neglect on the part of their men in the performance of duty."

"Foremen may dismiss or suspend from duty any employe under their control. They must treat the men under them with consideration, and must not use abusive or profane language toward them. Laborers who habitually fail to give satisfaction should be dismissed."

(A. R. E. and M. of W. Assn. rules adopted 1910.)

"They shall employ men as the ....(Title).......... directs, and see that they properly perform their duties. They must keep the required records of the time of their men and of the materials used."

PROPOSED RULE.

Change and addition to above rule to read as follows (*italic*):

They shall employ men as the ......(Title)........ directs. *They must treat employes with consideration,* and see that they properly perform their duties. *They shall discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause.* They must keep the required records of the time of their men and of the materials used.

DRAINAGE.

General.

(Twenty books contain rules on "Drainage.")

Examples of rules in actual use:

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 44.)

"Good drainage is most essential, and the farther water is removed from the track and the sooner it can be diverted from the roadbed, the more stable will become the track."

(Canadian Pacific Ry., M. of W. Rules, November, 1907, page 21.)

"The worst enemy of the roadbed is water, and the farther it can be kept away, or the sooner it can be diverted from the roadbed, the better the track will be protected."

(Union Pacific R. R., Rules for M. of W. and Str., April, 1909, page 39.)

"The most important factor, by far, in the maintenance of good track is drainage. Water is the worst enemy of track, and it should be the aim of every track foreman to lead it as quickly and as far as possible from his roadbed. Every hour spent in perfecting drainage will be repaid many fold in lessened repairs."

PROPOSED RULE.

Special attention must be given to the proper drainage of the roadbed for the maintenance of good track. This is essential, and the farther water can be kept away, or the sooner it can be diverted from the roadbed, the better the track will be protected.

Construction.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 44.)

"Ditches shall, at all times, be in good condition, and they must be in accordance with standard plans. They shall be generally parallel with the track, except at inlets and outlets, where they should diverge from the roadbed so as not to injure the embankments. They must be of the necessary size to pass all water freely during the heaviest freshets."

(Penna. Lines W. of P., Instr. for M. of W. Dept., August, 1905, page 4.)

"Ditches shall be as shown on the standard drawing, graded parallel with the track, so as to pass water freely during heavy rains and thoroughly drain the ballast and roadbed. The line of the top edge of the ditch must be parallel with the rails, and well and neatly defined at the standard distance from the rail, except at inlets and outlets, where they should diverge from the roadbed, so as not to injure embankments."

PROPOSED RULE.

Ditches shall be constructed in accordance with the standard drawing of the sizes necessary to thoroughly drain the roadbed and afford free flow of all water during heavy rains. The line of the top edges of ditches must be well and neatly formed, and be parallel with and at the standard distance from the rails, except at inlets and outlets, where ditches should diverge from the roadbed to prevent damaging embankments.

(El Paso & Southwestern, Rules of M. of W. Dept., April, 1906, page 36.)

"Where ditches cannot be drained into natural waterways, special instructions must be asked before doing the work."

PROPOSED RULE.

Ditches should be drained into natural waterways. At locations where this is impossible or impracticable, special instructions must be obtained from the proper authority previous to starting work.

Washing at Ends of Cuts.

(Louisville & Nashville R. R., Rules for M. of W. Employes, 1909, page 72.)

"Ditches at ends of cuts must be turned away from fills, so that slopes of fills may not be washed away."

(Burlington Route, Rules of Track, Bridges and Bldg. Depts., January, 1902, page 35.)

"Whenever the water washes the soil so as to approach too near to the ends of cuts or other places, special efforts must be made to stop such wash, and to fill up the washed places, so that the banks will be of full width, and the proper slope maintained."

(Illinois Central R. R., Rules of M. of W. Dept., 1909, page 6.)

"At the ends of cuts or other places where the water washes the soil or bed of the ditch so as to approach too near the track, special effort must be made to stop such wash and to fill the washed places by dams of brush, old ties or other effective methods, so the roadbed will not be reduced in width."

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 45.)

"Whenever water from any ditch, culvert or stream approaches too near to the roadbed and washes the soil, special efforts must be made to stop the wash, and fill up the gullies, so that the roadbed will be of the full width, with slopes of not less than one and one-half feet horizontal to one foot vertical."

PROPOSED RULE.

When the roadbed is endangered by water from ditches or other waterways approaching too close thereto, causing washing of the soil, the gullies shall be filled up, and special efforts made to prevent continuance of the wash.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 45.)

"Standard cross-drains must be used where necessary to obtain proper drainage."

(Penna. Lines W. of P., Instr. for M. of W. Dept., August, 1905, page 4.)

"Cross-drains shall be put in at proper intervals where necessary."

(Canadian Pacific Ry., M. of W. Rules, November, 1907, page 22.)

"Box cross-drains should be put in wherever necessary; they must be placed deep enough and upon such grade as will thoroughly drain the ditch from which they lead. They must not be placed where slopes of embankments or side hills will be washed away unless properly protected."

PROPOSED RULE.

Cross-drains shall be installed where necessary. They shall conform to the standard drawing and be placed at the depths and to the grades required to obtain proper drainage.

Surface Ditches.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 44.)

"Where necessary, surface ditches shall be made on the tops of cuts, to prevent surface water from washing the sides thereof. These ditches shall be not less than three feet from the edge of the cut."

(Penna. Lines W. of P., Instr. for M. of W. Dept., August, 1905, page 5.)

"Berme ditches, where provided to protect the slopes of cuts, must be kept open. These ditches should not be closer than five feet to the edges of the cuts."

(Canadian Pacific Ry., M. of W. Rules, November, 1907, page 21.)

"Surface water should be intercepted by surface ditches on the upper side of cuts when necessary or practicable."

(Louisville & Nashville R. R., Rules for M. of W. Employes, 1909, page 73.)

"Surface ditches should be cut at least ten feet above the top of the slope of sidehill cuts, except when the natural material is such as to be likely to slide on account of them. In such cases a ditch shall not be dug, but a dam constructed to keep the water ten feet from the top of the slope. The material for the dam must not be taken from any place where injury to the slope may result. No water other than rainfall should be allowed to run down slopes of cuts if practicable to avoid it."

(Burlington Route, Rules of Track, Bridge and Bldg. Depts., January, 1902, page 35.)

"Surface ditches must be made outside the slopes of cuts, leaving a sufficient berme between the slope and the ditch wherever the general drainage of the ground is toward the cut."

PROPOSED RULE.

Rule of Canadian Pacific Railway (as above).

Road Crossings.

(Illinois Central R. R., Rules of M. of W. Dept., 1909, page 6.)

"At road crossings where drainage is needed, vitrified pipe of the proper size should be used, and, when necessary, the ends should be protected by a wall. When the drainage of a highway is toward the track, care must be taken to divert the water away from the roadbed."

PROPOSED RULE.

Road crossings shall be drained in accordance with the special instructions given by the proper authority in each particular case.

Wet Cuts, Etc.

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 45.)

"When efficient side ditches cannot be economically maintained in wet cuts, owing to the character of the ground, or lack of space, the ditches should be underdrained by means of stone, tile pipe or other methods, as may be directed by the Division Engineer."

(Illinois Central R. R., Rules of M. of W. Dept., 1909, page 6.)

"Drain tile should be used in wet cuts to secure better drainage, the size of tile and method of laying to be determined by the Roadmaster. Where drain tile is used, the upper end should be plugged and the lower end covered with proper grating, and provided with suitable protection from wash and frost. Extreme care must be used to see that the tile is laid below the frost line. A covering of cinders, gravel or slag can be used to advantage where the soil is impervious to water."

PROPOSED RULE.

When side ditches in wet cuts afford insufficient drainage, drain pipes shall be used. The pipes shall be of the quality and dimensions required and shall be laid, as directed, by the proper authority.

Berme, Etc.

(Illinois Central R. R., Rules of M. of W. Dept., 1909, page 6.)

"A berme or space of at least five feet must be left between the foot of the embankment and the edge of borrow pits or ditches from which material is taken, for constructing or widening banks. Slopes of borrow pits on the side next to the track must be uniform and not steeper than one to one. All borrow pits or ditches must be drained where practicable."

Disposition of Earth.

(Ten books contain rules on "Disposition of Earth.")

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, p. 45.)

"Earth from ditches or elsewhere must be deposited over the sides of adjacent embankments, immediately leveled off, and under no circumstances shall it be thrown on the sides of cuts."

(Penna. Lines W. of P., Instr. for M. of W. Dept., August, 1905, p. 4.)

"Earth taken from ditches in cuts or elsewhere must not be left at or near the ends of ties, nor thrown upon the slopes of the cuts, nor on the ballast, but must be dumped and distributed over the sides of embankments."

(Canadian Pacific Ry., M. of W. Rules, November, 1907, page 22.)

"Material taken from ditches or elsewhere must be deposited on the slopes of embankments, below the ballast, and not be put on the tops or slopes of cuts."

(Union Pacific R. R., Rules for M. of W. and Star., April, 1909, p. 39.)

"Material should not be cast where it can be washed back into ditches."

PROPOSED RULE.

Rule of Canadian Pacific Ry., as above.

Maintenance, Etc.

(N. Y. C. & H R. R. R., Rules of M of W. Dept., August, 1906, p. 44.)

"During the fall, especial attention shall be given to ditching. All new ditches should be dug and all old ditches cleaned before the winter sets in."

(Penna. Lines, Instr. for M. of W. Dept., August, 1905, page 4.)

"All ditches must be cleaned early in the spring, and late in the fall."

Prevent private land owners from diverting drainage into ditches, etc.

(Three books contain rules on "Obstructing Ditches, Etc.")

(Penna. Lines, Instr. for M. of W. Dept., August, 1905, page 5.)

"No work on old or new drains or ditches for public or private use on the Railway Company's right-of-way must be permitted without proper authority. Farmers or others must not be permitted to connect their drains or ditches with the company's ditches."

(N. Y. C. & H. R. R. R., Rules of M. of W. Dept., August, 1906, page 78.)

"If adjoining land owners obstruct the ditches or culverts, Section Foremen shall endeavor to prevent them from doing so, and, in event of failure, they must report the facts to the Supervisor."

(El Paso & Southwestern, Rules of M. of W. Dept., April, 1906, page 36.)

"In no case must water be diverted through private lands, or from its natural channels along company's grounds, for the purpose of protecting adjoining private lands from overflow, except under contract in writing approved by the head of the Maintenance of Way Department."

PROPOSED RULE.

The construction of ditches or drains, for public or private use, on lands of the company, must not be permitted except by proper authority.

Adjoining land owners must not be permitted to connect ditches or drains with, or divert water into, the company's ditches or drains without proper authority.

Adjoining land owners must not be allowed to obstruct the company's ditches or drains.

Water must not be diverted through private lands or from its natural channels, along the right-of-way, except by proper authority.

DISCUSSION.

(The report of the Committee on Rules and Organization was presented by the Chairman, Mr. Jos. O. Osgood, Chief Engineer, Central Railroad of New Jersey.)

Mr. Jos. O. Osgood (Central of New Jersey) :—The Committee on Rules and Organization submits for your approval certain additions and revisions of rules passed by the Association for publication in the Manual.

The first change is in rule 4, of the "General Notice," and is to read as follows:

"4. Employés must exercise care and watchfulness to prevent injury to themselves, other employés and the public, and to prevent damage to property. In case of doubt they must take the safe course. They must know that all tools and appliances are in safe condition before using. They must move away from tracks upon approach and during passage of trains, and, so far as practicable, prevent the public from walking on tracks or otherwise trespassing on the right-of-way."

Under the heading "General Notice," add two new rules as follows:

"10. Employés must not without proper authority absent themselves from duty, exchange duties with others or engage substitutes.

"11. Employés must conduct themselves properly at all times. They must be civil and courteous to fellow-employés and patrons of the road. Employés who are dishonest, vicious, quarrelsome, or use profane, vulgar or immoral language, must be discharged."

Under "Rules Governing Track Foremen, Bridge and Building Foremen and Signal Foremen," rule 4 in each case to be revised to read:

"4. They shall employ men as the ....(Title)....directs. They must treat employés with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used."

Under "Rules Governing Track Foremen," rule 5 to be revised so that the last clause shall read:

"Foremen must provide themselves with reliable watches, and, when possible, compare time daily with a standard clock or with the watches of other employés who are required to have the standard time."

Mr. William McNab (Grand Trunk) :—In regard to rule 11, I think this Association should not go on record as limiting the range of politeness to be extended by employés of any road. It is stated here, "Employés must conduct themselves properly at all times. They must be civil and courteous to fellow-employés and patrons of the road." It seems to me if an employé is courteous or civil to anyone not a patron of the road, such a one might be induced to become a patron of that road. I think there should be something to change this limiting of the range of politeness or courtesy. It is not right to confine it to the patrons of the road.

Mr. C. E. Lindsay (New York Central & Hudson River) :—I quite agree with the views expressed by Mr. McNab. These rules are to be inserted in the Manual, and they should be expressed in the plainest Anglo-Saxon that we can get. That clause might well stop with the word "courteous"—"they shall be civil and courteous."

I have one other objection, and that is to the opening of clause 4, which reads, "Employés must exercise care and watchfulness to prevent injury to themselves, other employés and the public, and to prevent damage to property." I think the word "take" would be better than the word "exercise." The words "and watchfulness" are redundant and unnecessary. "Take" is a short, sweet word. The first part seems to be addressed to the employé and the latter part to the employer. The word "must" in the last line should be "will"—"will discharge"—giving warning to the employé that he will be discharged if he violates the rules.

Mr. A. W. Johnston (New York, Chicago & St. Louis) :—I desire to add my approval to the suggestions made by Mr. McNab and Mr. Lindsay. I think they are quite timely.

Mr. Osgood:—May I ask how that leaves clause 11? Do I understand it is to read: "Employés must conduct themselves properly at all times. They must be civil and courteous?"

Mr. Lindsay:—Stop with the word "courteous," and substitute "will" for "must" in the last line.

Mr. Osgood:—Then, in the next sentence, "Employés who are dishonest, vicious, quarrelsome, or use profane, vulgar or immoral language, will be discharged?"

The President:—The word "will" is to be substituted for "must." Is that acceptable?

Mr. Lindsay:—That is acceptable.

Mr. P. C. Newbegin (Bangor & Aroostook) :—It would hardly seem to me that we want to go on record as stating that employés will be discharged if they use profane language. It is best, in my judgment, to have no rules that are not to be enforced.

Mr. Azel Ames (United States Block Signal and Train Control Board) :—There is another thing that I do not like about that rule, and that is that it threatens. I do not think it is proper in any rule of a railroad to state, "If you do this, you will be discharged." It is assumed that a man will be discharged for non-obedience to the rules, if that non-obedience is flagrant or frequent enough, but I do not think any specific rule should embody in it the threat that if the man does not obey that particular rule he will be discharged.

Mr. McNab:—I think the last clause of this rule should not stand. It would require unusual perception to determine the degree of vulgarity or dishonesty or any other feature connected with these qualifications.

Any well-regulated railroad will see that employés are discharged if they are guilty of that, and I move that the last clause be eliminated.

Mr. George W. Kittredge (New York Central & Hudson River):—In reference to this question about profanity, I heard the other day a story which is apropos. A family—father, mother and daughter of fifteen or sixteen—were discussing some of their acquaintances, and it so happened that three or four of the people they had been discussing were recently married young persons who had not been particularly successful in business ventures. After the husband had said on three of four occasions, "he don't seem able to succeed," and the wife had remarked, "Well, now, he is such a very nice, moral young man," the young lady spoke up and said, "Well, papa and mamma, I want to give you notice now, that if ever I get married, I am going to marry somebody that swears and smokes."

The President:—The motion, which has been seconded, is that the last clause of rule 11 be eliminated.

(The motion carried.)

Mr. Lindsay:—Mr. President, in rule 4 I would like to substitute the words "take care"——

The President:—The Committee does not think that will improve the rule. If there is no further objection the rule will stand.

Mr. C. H. Spencer (Washington Terminal Company):—One of the hardest rules that we have to enforce is to bring employés to the point of keeping trespassers off the track. We have had that experience in Washington, and I hope to see that rule stand.

The President:—If there is no further discussion, rule 4 will stand.

Mr. C. C. Wentworth (Norfolk & Western):—I think there should be a clause in rule 4 saying, "When employés are working on double tracks, they should get off of both tracks when trains are approaching." I make a motion to that effect.

Mr. Osgood:—I would say the same objection occurs to this that has been made in regard to some of the other clauses. There is always great danger of amplifying these rules so that they will be cumbersome and of no use. I personally agree with the changes that have so far been made, but the Committee in discussing these matters found there was a demand for certain things which we had not included in the rules last year, and we took the best judgment we could get on the subject and have submitted these rules for your consideration.

The President:—It seems to the Chair the Committee has covered that by putting the word "tracks" in the plural.

Mr. B. H. Mann (Missouri Pacific):—It seems to me that in rule 4 the words "they must move away from tracks upon approach and during passage of trains"—that the words "and during passage of trains" should be eliminated, as they do not add to the meaning. The rule is strong enough without them, and we imply perhaps something that is not intended.

The President:—I think it is understood an engineer would have enough sense to get out of the way without the rule. If there is no further objection to rule 4, it will stand as submitted by the Committee. Is there any further discussion on rule 10?

Mr. Lindsay:—I ask if the Committee will omit the word "proper" from the first line?

The President:—That is satisfactory to the Committee. If there is no further discussion of rule 10, we will pass to rule 11.

Prof. S. N. Williams (Cornell College):—If it is the intention to shorten the rules, might not the words "civil and" be eliminated, so as to make the rule read "they must be courteous to fellow-employés," etc.? Or it might be better to have the rule read as follows: "Employés must conduct themselves properly at all times, and be courteous to fellow-employés and patrons of the road," etc.

The President:—That is acceptable to the Committee. Is there any further discussion?

Mr. Osgood:—Under rule 4 it now reads: "They shall employ men as the....(Title).... directs, and see that they properly perform their duties. They must keep the required records of the time of their men and of the materials used." It is proposed that the rule shall be revised to read as follows: "They shall employ men as the...(Title)..... directs. They must treat employés with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used."

The President:—If there is no objection to this rule, it will stand approved as submitted.

Mr. Osgood:—Under rule 5, governing track foremen, it now reads: "Foremen must provide themselves with reliable watches, and, when possible, compare time daily with a standard clock or with conductors' watches." The last sentence was criticized at the last convention, and has been revised so as to read as follows: "Foremen must provide themselves with reliable watches, and, when possible, compare time daily with a standard clock, or with the watches of other employés who are required to have the standard time." I believe the criticism last year was that we should make other watches than the conductors' watches available for the purpose.

Mr. McNab:—If these rules are to be incorporated in the Manual, there should be no ambiguity in regard to the meaning of any word. A man might compare his watch and put it in his pocket and do nothing more than that. I think the word "verify" would be a better word to use. I ask the Committee if they will accept the word "verify" instead of compare."

The President:—That change is acceptable to the Committee. If there is no further discussion on this rule, it will be adopted as amended.

Mr. Osgood:—The following is contained in the report: "Under the second instruction of the Board of Direction, it is recommended that rules 1, 2, 3, 4, 5 and 6, under the heading "Inspection of Track," now published on page 66 of the Manual, be omitted in future revisions." That matter was brought up at the last convention, and it was my understanding that that change would be made. It is simply to eliminate a certain amount of language from the Manual, as it will all be noted in another place.

The President:—If the convention desires to have these rules read, they will be read on request. If not, the Committee's recommendations will be adopted.

Mr. Osgood:—The new rules have been accepted by the Track Committee, which originated the rules on that subject, so there is no discrepancy in the two sets of rules. It is simply to have them appear in one place instead of two.

Under the third instruction, it is recommended that "the instructions to next year's Committee provide that rules in the nature of specifications or instructions regarding the conduct of work be prepared, making use of the recommendations of the various committees dealing with these subjects and of the best practice of railway companies, as embodied in their Books of Rules, with a view to providing material which may be of assistance to railways formulating Maintenance of Way rules. It is understood that in preparing such rules the Committee will confer with other committees whose work is affected thereby."

We got to the point where there was nothing for the Committee to do except to take in a different class of rules than those which had heretofore been considered by the Committee, and after looking into the matter, it seemed as though that was the natural way to continue the work of the Committee if it was so desired.

The President:—The meeting is open to suggestions from the members on the future work of this Committee. It is very useful to the Committee to know what the wishes of the Association are with reference to its work and along what lines it should proceed. By reading the report of the Committee it will be found that this Committee has done an immense amount of work during the year. It examined the rules of sixty-one railways and tabulated and compiled the information, which in itself is a large task. These rules were classified under eight different heads, and conclusions were drawn therefrom.

Mr. Osgood:—I will say in that connection that the eight rules selected represent a very small portion of the rules examined. We found after making a record of the rules, indicating what companies had rules on certain subjects and sub-subjects, that there were certain variations. We then selected a certain number of the rules, made comparisons between the forms, selecting those which seemed to us best, and have submitted a small number of these rules as an appendix. I will say that I have a few copies of the compilation which shows the different subjects on which the different railway companies have rules, and if any of the members are preparing Maintenance of Way rules, it may be an advantage to have a copy of this compilation. The rules printed in the appendix represent a smaller compilation made after looking over the Maintenance of Way rules of a considerable number of railways. Of course, in some cases, only two or three railways have adopted certain rules, and in other cases the rules have been adopted by twenty or thirty companies, possibly not exactly the same rules, but very much alike.

Mr. H. A. Lloyd (Erie):—As to the clause about the foremen verifying their watches—that is applicable to all foremen. Do I understand that the rules for governing track foremen, bridge and building foremen, and signal foremen, are entirely separate, and this clause is added to each one, or is it to be in the General Rules? In reading over some of the rules I notice they have an entirely different set of rules governing the track foremen, another set governing the bridge and building foremen, and another set governing the signal foremen, and incorporated with each of these are a number of clauses and paragraphs which are applicable to each one; this makes a voluminous book. It seems to me that could be avoided.

The President:—The Committee in formulating its work in the preparation of a general book of rules will take these suggestions under consideration. Wherever it is possible to make a general rule applicable to all employés, it will compile it as a general rule so as to avoid repetition.

If there is no further discussion the Committee will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE X.—ON SIGNALS AND INTERLOCKING.

(Bulletin 130.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

During the past year your Committee has met as follows:

Chicago, March 15, 1910. Entire Committee. Present: Messrs. Ames, Anthony, Denney, Eck, Elliott, Hovey, Mock, Patenall, Peabody, Rhea, Stevens, Taussig, Wendt, and Rudd, Chairman. Absent: Messrs. Balliet, Cable, Christofferson, Clausen, Ellis, Harahan, Ingalls, Scott and Temple.

Niagara Falls, June 8, 1910. Entire Committee in conference with Committee on Transportation of the American Railway Association. Present: Messrs. Ames, Anthony, Cable, Clausen, Eck, Elliott, Hovey, Mock, Rhea, Scott, Stevens, Wendt, and Rudd, Chairman. Absent: Messrs. Balliet, Baker, Besler, Causey, Christofferson, Denney, Harahan, Ingalls, Patenall, Peabody, Temple and Young.

Chicago, November 14, 1910. Entire Committee. Present: Messrs. Ames, Anthony, Baker, Causey, Clausen, Denney, Eck, Elliott, Harahan, Hovey, Mock, Patenall, Peabody, Rhea, Stevens, Wendt, Young, and Rudd, Chairman. Absent: Messrs. Balliet, Besler, Christofferson, Ingalls, Scott and Temple.

The Board of Direction assigned seven subjects for consideration:

(1) Revision of Manual.

(2) Continue investigation of outline and description of a complete and uniform signal system, suitable for general adoption, conferring with proper Committee of the American Railway Association on the subject.

(3) Revise Mechanical Interlocking Specifications presented in Bulletin 108, and include wrought-iron pipe as well as steel.

(4) Review and resubmit Electric Interlocking Specifications, with statement of the results from experience.

(5) Confer with Committee on Ties, and make report on the effect of treated and metal ties on track circuits.

(6) Confer with Committee on Yards and Terminals, in regard to capacity of terminal layouts.

(7) Make concise recommendations for next year's work.

In addition, the Committee on Track requested a conference, which was held.

To handle these subjects, Sub-Committees were appointed during the year; the letters, as far as possible, corresponding to those used in previous years.

Subject No. 1.—Revision of Manual:

Sub-Committee "D"—Messrs. Ames, Balliet, and Wendt, Chairman.

Subject No. 2.—Uniform Signal System:

Sub-Committee "B"—To prepare statement to be submitted to the proper Committee of the American Railway Association: Messrs. Stevens and Anthony. Met in Buffalo, April 5, and completed its work.

Sub-Committee "J"—Elected by the entire Committee to represent it when called into further conference by the Committee on Transportation of the American Railway Association: Messrs. Anthony, Clausen, Patenall, Stevens, and Rudd, Chairman. It has not been called.

Sub-Committee "C"—To report on the indications after the Committee on Transportation has made a decision on the points of difference between the majority and minority as brought out at the last annual meeting: Messrs. Baker, Besler, Cable, Causey, Clausen, Harahan, Ingalls, Scott, Temple, and Rudd, Chairman. No meetings.

Sub-Committee "A"—On aspects: Messrs. Patenall, Peabody, Stevens, Young, and Anthony, Chairman. No meetings.

Subjects Nos. 3 and 4.—Mechanical and Electric Interlocking Specifications:

Sub-Committee "E"—Messrs. Anthony, Patenall, Peabody, Stevens, and Mock, Chairman. Met at Chicago, November 14, all members present.

Subject No. 5.—Effect of Treated and Metal Ties on Track Circuits:

Sub-Committee "F"—Messrs. Christofferson, Elliott, Eck, Hovey, Mock, Rhea, and Denney, Chairman. No meetings held.

Subject No. 6—Conference with Committee on Yards and Terminals:

Sub-Committee "G"—Messrs. Balliet, Eck, Peabody, Wendt, Young, and Elliott, Chairman. One meeting—Niagara Falls, September 16, 1910. Present: Mr. Eck. Absent: Messrs. Balliet, Elliott, Peabody, Wendt and Young.

Subject No. 7.—Recommendations for Next Year's Work:

Sub-Committee "H"—Messrs. Ames, Clausen, Denney, and Rudd, Chairman. One meeting, Chicago, November 14, 1910. All members present.

Conference with Committee on Track—Special:

Sub-Committee "K"—Messrs. Ames, Anthony, Elliott, Patenall, and Rudd, Chairman. Mock afterward substituted for Rudd, as Chairman. Meetings—New York, September 7, 1910. Present: Messrs. Ames, Anthony, Patenall, and Rudd, Chairman. Absent: Mr. Elliott. Chicago, October 21 and 22, 1910. Present: Messrs. Elliott, Patenall, and Mock, Chairman. Absent: Messrs. Ames and Anthony.

Subject No. 1.—Revision of Manual.

Specifications for Rubber-Covered Wire were adopted March, 1909, and are in the Manual. New specifications have been accepted by the Railway Signal Association and sent to letter-ballot for approval.

It has been the policy of this Association to let the Railway Signal Association work out details of signal appliances and to adopt only after adoption by the Railway Signal Association. We, therefore, offer, for the reasons set forth in the report following—

This Conclusion—That the revised Specifications for Mineral Matter Rubber Compound Insulated Signal Wire be adopted by the Association and printed in the Manual.

The changes from present specifications are as follows·

Title has been changed by inserting the words "Mineral Matter Rubber Compound," as being indicative of the general character of the insulation this specification was drawn to cover, and which is, with the exception of certain other compounds, the type of insulation generally required.

In Clause 1, Conductors, the words "weld or joint" have been inserted as more fully explaining the requirement that a conductor is desired that is of one piece as coming from the wire drawing machines.

Clauses 2 and 3, Rubber Insulation, have been changed to eliminate all references to quantities which are given under Clause 17, and the word "Upriver" has been inserted as specifying the quality of rubber desired, there being a number of grades of Para rubber and the Upriver is the best of these.

Clause 4, Braiding, has been changed to eliminate the taping, which was useful only as a mechanical protection, and, besides being quite expensive, was not deemed necessary.

Clause 5, Acceptance, is new and is required to enable the purchaser to assure himself as far as practicable before the product has been manufactured that a satisfactory compound will be furnished.

Clauses 6 and 7, Tests, are practically the same as in the present specification, while clause 8, in regard to interpreting the result of the chemical analysis of the compound, is new. The necessity for this clause is obvious if an analysis is made of the compound.

Clause 9, Physical Test of Copper Conductors, has been changed to eliminate all tests except those of elongation and the simple bending tests, these being ample to insure the desired quality of material.

Clause 10, Conductivity Test of Copper, and Clause 11, Test of Tinning, are unchanged, while Clause 12, requiring an excess of sulphur in the sodium sulphide solution, has been added, as, without this requirement, the test for tinning is valueless.

Clause 13, Tests of Braiding, is unchanged.

Clauses 14, 15 and 16, Physical Tests of Rubber Insulation, have been changed to specify the rate at which the sample shall be stretched, that the tensile strength per square inch shall be one thousand (1,000) instead of eight hundred (800) pounds, that the test shall be made on a separate sample from that on which the stretching test is made and that the specific gravity shall not be less than 1.75. The increase in tensile strength is recommended, as, when properly made, a thirty (30) per cent. Para rubber compound will meet this requirement, and a compound which contains less quantity of rubber or is of an inferior grade of rubber cannot so readily be made to meet this requirement.

The specific gravity of the rubber compound is specified with the idea of securing a compound of a certain density, and to make unlikely the use of fillers which have but little body.

Clause 17, Chemical Tests of Rubber Insulation: This clause calls for the thirty (30) per cent. of rubber and seven-tenths (0.7) per cent. of free sulphur which is required by the present specification, but in the other requirements is practically new and calls for the best practice from a chemical standpoint that could be devised. In connection with chemical analysis, these requirements are regarded as of the greatest importance as insuring to a greater extent than any of the other requirements that a compound will be obtained which will contain the desired quantity of rubber and be of a satisfactory chemical combination.

Clause 18, Electrical Tests of Rubber Insulation, is the same as the present specification, the one-third (⅓) increase in insulation resistance thought advisable by the Committee having been opposed by the manufacturers and, at their request, any recommendations on the subject have been postponed with a view to giving time for the manufacturers to demonstrate the correctness of the position taken by them.

Clause 19 has been changed to require that the wire will be arranged in coils for testing to permit of an easy inspection, which is not possible when the wire is wound on a reel.

Clauses 20, 21 and 22, specifying the length of the wire and size of coils, are new, and are required owing to the practice now being followed of making a wire continuous from one binding post to the other and eliminating joints, which are difficult to keep up and are a cause of comparatively frequent failures.

Clauses 23, 24 and 25, Packing for Shipment, are new, and prescribe the methods to be followed when wire is to be shipped.

REVISED SPECIFICATIONS FOR MINERAL MATTER RUBBER COMPOUND INSULATED SIGNAL WIRE FOR CURRENT OF 660 VOLTS OR LESS.

Conductors.

1. Conductors must be of soft-drawn, annealed copper wire having a conductivity of not less than ninety-eight (98) per cent. of that of pure copper, Matthiessen's standard. Each wire forming a conductor must be continuous without weld, splice or joint throughout its length, must be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy, uniform coating of tin.

Rubber insulation.

2. The rubber insulation shall be made exclusively from pure Upriver, fine, dry, Para rubber, of best quality, which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sulphur, properly and thoroughly vulcanized. Before being mixed with the other ingredients the rubber shall be thoroughly washed and dried.

3. The insulation must be homogeneous in character, tough, elastic, adhering strongly to, and be placed concentrically around the wire.

Braiding.

4. The rubber insulation must be protected with one layer of closely woven cotton braiding at least one-thirty-second ($\frac{1}{32}$) of an inch thick, saturated with a black insulating weatherproof compound that shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 200 degrees Fahrenheit.

Acceptance.

5. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the wire furnished and the acceptance of the same shall be made by the purchaser.

Tests.

6. The manufacturer shall provide at his factory apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

7. Tests shall be made from samples taken from any part of any coil and may also be made upon the finished product immediately after being delivered. If the requirements of this specification are not met the wire will be rejected and the manufacturer shall pay freight charges for return of such material.

8. At the option of the purchaser the wire, after being tested, shall not be shipped from the factory until an analysis of a sample has been made by a chemist chosen by the purchaser, and the results of such analysis, as interpreted by the purchaser shall be sufficient ground for rejection should the wire or insulation not conform to the requirements of this specification.

Physical test of copper conductors.

9. Each solid conductor must stand an elongation of twenty-five (25) per cent. of its length in ten (10) inches before breaking, and must be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

Conductivity test of copper.

10. The conductivity of the copper shall be determined by measuring the resistance of a length of the wire and comparing with Matthiessen's standard of copper resistance.

Test of tinning.

11. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times and if the sample does not become clearly blackened after the fourth immersion, the tinning shall be regarded as satisfactory.

12. The sodium sulphide solution must contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

Tests of braiding.

13. A six (6) inch sample of wire with carefully paraffined ends shall be submerged in fresh water of a temperature of 70 degrees Fahrenheit for a period of twenty-four (24) hours. The difference in weight of the sample before and after submersion must not be more than ten (10) per cent. of the weight of the sample before submersion, less the weight of the copper and vulcanized rubber.

Physical tests of rubber insulation.

14. A sample of the vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The sample shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths ($2\frac{7}{16}$) inches apart. The sample shall then be stretched until the marks are nine (9) inches apart before breaking.

15. The tensile strength of the rubber insulation as shown by tests made on a carefully prepared sample shall be not less than one thousand (1,000) pounds per square inch. The sample for five (5) minutes before and as near as practicable during the test shall be maintained at a temperature of 70 degrees Fahrenheit.

16. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical tests of rubber insulation.

17. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent. of pure Upriver, fine, dry, Para rubber of best quality; not more than four (4) per cent. of waxy hydro-

carbons consisting of refined paraffine or pure ozokerite; not more than 0.7 per cent. of free sulphur; not more than 2.5 per cent. total sulphur; freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical tests of rubber insulation.

18. The circular mills cross-section, the thickness of the rubber insulation (measured at the thinnest point), the minimum insulation resistance in megohms per mile and the dielectric strength for the various sizes of wire shall conform to the following requirements:

Size B. & S. Gage.	Area in Circular Mills.	Thickness of Insulation.	Insulation Resistance Meghoms Per Mile.	Test Voltage Alternating Current.
0	105,592	⅛-in. wall	900	10,000
1	83,694	⅛-in. wall	1,100	10,000
2	66,373	⅛-in. wall	1,200	10,000
4	41,742	3-32 in. wall	1,100	9,000
6	26,250	3-32-in. wall	1,300	9,000
8	16,509	3-32-in. wall	1,600	9,000
9	13,090	5-64-in. wall	1,500	7,000
10	10,380	5-64-in. wall	1,600	7,000
12	6,530	5-64-in. wall	1,900	7,000
14	4,107	5-64-in. wall	2,100	7,000
16	2,583	1-16-in. wall	2,100	4,000
18	1,624	1-16-in. wall	2,400	4,000

19. The test for insulation resistance must be made upon all wire after at least twelve (12) hours' submersion in water and, while still immersed, results be corrected to a water temperature of sixty (60) degrees Fahrenheit. Tests must be made with the wire in coils, suitable for examination, and before the application of braid or other covering, with a well-insulated battery and galvanometer, with not less than one hundred (100) volts, and readings must be taken after one minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

Coils.

20. The wire shall be furnished in coils of the length named for the following sizes of wire:

B. & S. Gage.	Length in Feet.
No. 14	2,000
No. 12	1,500
No. 10	1,500
No. 8	1,500
No. 6	1,000

21. Twenty (20) per cent. of the coils will be accepted if five hundred (500) feet long or over, or of any length where a coil, submitted for inspection and testing, has been cut to secure a sample for testing.

22. The inside diameter of a coil shall, unless otherwise specified, be not less than twenty (20) nor more than twenty-two (22) inches.

Packing for shipment.

23. The wire shall be shipped in reels or coils, as directed by the purchaser.

24. If shipped on reels, they shall be amply strong and the wire shall be protected by lagging, to prevent injury in transportation. A tag must be placed inside of the lagging and a stencil on the outside of each reel, giving the weight, the length of each piece of wire, the size of the wire, the name of the manufacturer and purchaser's order or inspection number plainly marked.

25. If shipped in coils, each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

26. Each coil shall have the weight, length and size of wire, the name of maker and purchaser's order or inspection number plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

Specifications for cables, weatherproof wire, etc., are closely related to the subject of Rubber-Covered Wire. Although not specifically instructed by the Board of Direction, we, therefore, submit specifications for these and offer

This Conclusion—That the Specifications for Mineral Matter Rubber Compound Insulated Aerial Braided Cables, for current of 660 volts, or lower voltage service, be adopted by the Association and printed in the Manual, as its requirements are in accordance with the best practice, and, as far as applicable, are the same as those for rubber insulated wire given above.

SPECIFICATIONS FOR MINERAL MATTER RUBBER COMPOUND INSULATED AERIAL BRAIDED CABLES FOR CURRENT OF 660 VOLTS OR LESS.

General.

1. The cable bought under this specification will be used for........ .... current at .... volts and shall be.....................feet in length.

2. All workmanship and material shall be first-class and the best of their respective kinds, and shall be in full accord with the best modern electrical and mechanical practice.

Form of cable.

3. The cable shall consist of...................................... conductors insulated with rubber and stranded into cable with jute laterals to make round. The whole shall be taped and the core thus formed shall be wrapped with jute covered with a closely-woven braid, as herein specified.

Conductors.

4. Conductors shall be of the following sizes and numbers:

Number of Conductors.	Approximate Nearest Size B. & S. Gage Each Conductor.	Number of Strands.	Size of Strands.	Actual C. M. of Conductor.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

5. Conductors must be of soft-drawn, annealed copper wire, having a conductivity of not less than ninety-eight (98) per cent. of that of pure copper, Matthiessen's standard. Each wire forming a conductor must be continuous without weld, splice or joint throughout its length, must be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy, uniform coating of tin.

Rubber insulation.

6. The rubber insulation shall be made exclusively from pure Upriver, fine, dry, Para rubber of best quality, which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sulphur, properly and thoroughly vulcanized. Before being mixed with the other ingredients, the rubber shall be thoroughly washed and dried.

7. The insulation must be homogeneous in character, tough, elastic, adhering strongly to, and be placed concentrically around the wire.

Taping, filling and braiding.

8. The core of the cable must be made cylindrical in form and properly laid up, with one wire in each layer taped for a tracer. Cables of more than three (3) and less than seven (7) conductors shall be made up with a jute or sisal center. Each layer of core must have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. All interstices between insulated conductors must be thoroughly filled with dry jute to make round, and covered with a layer of rubber insulating tape overlapping for one-third (1/3) its width. The tape shall be of closely-woven cotton, filled with rubber insulating compound and laid to make a smooth surface.

9. A bedding of jute, not less than one-sixteenth (1/16) inch thick and saturated with tar, shall be wrapped over the taped core. A layer of tape, overlapping one-third (1/3) its width, shall be laid on over the jute in reverse order to the winding of the jute, and over this shall be placed one (1) layer of closely-woven cotton braiding at least one-thirty-second (1/32) inch thick, saturated with a black, insulating weatherproof compound that shall be neither injuriously affected by nor have an injurious effect on the braid at a temperature of 200 degrees Fahrenheit.

Acceptance.

10. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the cable furnished and the acceptance of the same shall be made by the purchaser.

Tests.

11. The manufacturer shall provide, at his factory, apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

12. Tests shall be made from samples taken from any part of any coil of wire and shall also be made upon the finished product before, and, if desired, immediately after being delivered. If the requirements of this specification are not met, the cable will be rejected.

13. At the option of the purchaser, the wire, after being tested, shall not be made into a cable until an analysis of a sample has been made by a

chemist chosen by the purchaser, and the results of such analysis, as interpreted by the purchaser, shall be sufficient ground for rejection, should the wire or insulation not conform to the requirements of this specification.

Physical test of copper conductors.

14. Each solid conductor must stand an elongation of twenty-five (25) per cent. of its length in ten (10) inches before breaking. It must be capable of being wrapped six (6) times about its diameter without showing any signs of breakage.

Conductivity test of copper.

15. The conductivity of the copper shall be determined by measuring the resistance of a length of wire and comparing with Matthiessen's standard of copper resistance.

Test of tinning.

16. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times and if the sample does not become clearly blackened after the fourth immersion the tinning shall be regarded as satisfactory.

17. The sodium sulphide solution must contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean, untinned copper wire in five (5) seconds.

Physical tests of rubber insulation.

18. A sample of vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The samples shall be stretched until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths ($2\frac{7}{16}$) inches apart. Samples shall then be stretched until the marks are nine (9) inches apart before breaking.

19. The tensile strength of the rubber insulation as shown by tests made on a carefully prepared sample shall be not less than one thousand (1,000) pounds per square inch. The sample, for five (5) minutes before and, as near as practicable, during the test, shall be maintained at a temperature of seventy (70) degrees Fahrenheit.

20. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical tests of rubber insulation.

21. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent. of pure Upriver, fine, dry, Para rubber, of best quality; not more than four (4) per cent. of solid waxy hydrocarbons consisting of refined paraffine or pure ozokerite; not more than 0.7 per cent. of free sulphur; not more than 2.5 per cent. total

sulphur, freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical tests of rubber insulation.

22. The thickness of the rubber insulation around each conductor (measured at the thinnest point), the minimum insulation resistance in megohms per mile when corrected to the standard temperature of 60 degrees Fahrenheit, and the dielectric strength shall conform to the following requirements:

B. & S. Gage.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
4	3-32 inch	1,100	9,000
6	5-64 inch	1,300	7,000
8	5-64 inch	1,600	7,000
9	5-64 inch	1,500	7,000
10	1-16 inch	1,400	4,000
12	1-16 inch	1,600	4,000
14	1-16 inch	1,900	4,000
16	3-64 inch	1,900	2,000

23. The test for insulation resistance must be made upon all wire after at least twelve (12) hours' submersion in water, and, while still immersed, results be corrected to a water temperature of sixty (60) degrees Fahrenheit. Tests must be made with the wire in coils, suitable for examination and before the application of tape or other covering, with a well-insulated battery and galvanometer, with not less than one hundred (100) volts, and readings must be taken after one minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

24. The cable, when made up after assembling and braiding, shall have the test voltage required for separate conductors, applied between conductors for five (5) minutes to each conductor.

25. The insulation resistance of each conductor shall be measured after test voltage has been applied to the completed cable, and the resistance found shall be not less than that specified for separate conductors.

Inspection.

26. The manufacturer shall notify the purchaser when the manufacture of the wire and cable is to begin, in order that inspection may be arranged for.

Reels.

27. Each cable shall be placed on a separate reel, holding the full length of cable. Both ends of cable must be accessible for testing, but be covered and protected from injury. The flanges of the reel shall be large enough to protect the cable in handling and rolling. The reels will be-

come the property of the purchaser, but must be taken back by the manufacturer upon the request of the purchaser.

Marking.

28. Each reel shall have the weight, length, number of conductors in cable, the name of maker and purchaser's order or inspection number plainly and indelibly marked on a strong tag securely fastened to the cable and also stenciled on the outside of the reel.

Notification.

29. The completed cable is not to be shipped from place of manufacture until permission in writing has been received from the purchaser. Should the cable, on arrival at destination, be found defective and not up to the specification requirements, it will be returned to the manufacturer, who must pay all freight charges.

MINERAL MATTER RUBBER COMPOUND, INSULATED, LEAD-COVERED, ARMORED SUBMARINE CABLE FOR 600 OR LOWER VOLTAGE SERVICE.

General.

1. The cable bought under this specification will be used under water for..............................current at........................ volts, and shall be.....................feet in length.

2. All workmanship and material shall be first class and the best of their respective kinds, and shall be in full accord with the best modern electrical and mechanical engineering practice.

Form of cable.

3. The cable shall consist of...................conductors insulated with rubber and stranded into cable with jute laterals to make round, the whole to be taped, and the core thus formed shall have lead sheath with jute covering over lead, with armor and a covering of jute over the armor as herein specified.

Conductors.

4. Conductors shall be of the following sizes and numbers:

Number of Conductors.	Approximate Nearest Size B. & S. Gage Each Conductor.	Number of Strands.	Size of Strands.	Actual C. M. of Conductor.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

5. Conductors must be of soft-drawn, annealed copper wire, having a conductivity of not less than ninety-eight (98) per cent. of that of pure copper, Matthiessen's standard. Each wire forming a conductor must be continuous without weld, splice or joint throughout its length, must be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy uniform coating of tin.

Rubber insulation.

6. The rubber insulation shall be made exclusively from pure Upriver, fine, dry, Para rubber, of best quality, which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sulphur properly and thoroughly vulcanized. Before being mixed with the other ingredients the rubber shall be thoroughly washed and dried.

7. The insulation must be homogeneous in character, tough, elastic, adhering strongly to, and be placed concentrically around the wire.

Taping and filling.

8. The core of the cable must be made cylindrical in form and properly laid up with one wire in each layer taped for a tracer. Cables

of more than three (3) and less than seven (7) conductors shall be made up with a jute or sisal center. Each layer of core must have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. All interstices between insulated conductors must be thoroughly filled with dry jute to make round, and covered with a layer of rubber insulating tape overlapping for one-third (⅓) its width.

9. The tape shall be of closely-woven cotton filled with rubber insulating compound and laid to make a smooth surface. The jute is to be well twisted and is to be applied spirally.

Sheath.

10. A sheath one-eighth (⅛) of an inch in thickness, consisting of an alloy of lead and tin, containing not less than ninety-eight (98) per cent. pure lead and from one (1) to two (2) per cent. tin, shall be applied over the assembled and taped conductors.

Armoring and braiding.

11. The sheath shall be protected by a layer of asphalt or tarred jute, well twisted and applied spirally and having a thickness of three-thirty-seconds ($\frac{3}{32}$) of an inch. Over the jute covering shall be placed a covering consisting of No. 4 B. & S. gage galvanized mild steel wires applied spirally and laid to fit closely one wire to the next.

12. Over the armoring a layer of closely woven jute braiding shall be placed at least one-sixteenth ($\frac{1}{16}$) inch thick, saturated with a black insulating weatherproof compound that shall be neither injuriously affected by nor have an injurious effect upon the braid at 200 degrees Fahrenheit.

Acceptance.

13. The product of those concerns only will be accepted who have satisfied the purchaser that the requirements of this specification will be complied with. The decision as to the quality of the cable furnished and the acceptance of the same shall be made by the purchaser.

Tests.

14. The manufacturer shall provide at his factory apparatus and other facilities needed for making the required physical and electrical tests. The manufacturer shall give free access to the place of manufacture and opportunity for inspecting and testing the product at all stages of manufacture to show that the required amount and quality of Para rubber and other ingredients are being used in the compound.

15. Tests shall be made from samples taken from any part of any coil of wire and shall also be made upon the finished product before, and, if desired, immediately after being delivered. If the requirements of this specification are not met the cable will be rejected.

16. At the option of the purchaser, the wire after being tested shall not be made into a cable until an analysis of a sample has been made by a chemist chosen by the purchaser, and the result of such analysis, as interpreted by the purchaser, shall be sufficient ground for rejection, should the wire or insulation not conform to the requirements of this specification.

Physical test of copper conductors.

17. Each solid conductor must stand an elongation of twenty-five (25) per cent. of its length in ten (10) inches before breaking. It must be capable of being wrapped six (6) times about its diameter without showing signs of breakage.

Conductivity test of copper.

18. The conductivity of the copper shall be determined by measuring the resistance of a length of wire and comparing with Matthiessen's standard of copper resistance.

Test of tinning.

19. Samples of wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation shall be repeated three (3) times, and if the sample does not become clearly blackened after the fourth immersion the tinning shall be regarded as satisfactory.

20. The sodium sulphide solution must contain an excess of sulphur and should have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

Physical tests of rubber insulation.

21. A sample of vulcanized rubber insulation not less than four (4) inches in length shall have marks placed upon it two (2) inches apart. The samples shall be stretched at the rate of three (3) inches per minute until the marks are six (6) inches apart and then at once released. One (1) minute after such release the marks shall not be over two and seven-sixteenths ($2\frac{7}{16}$) inches apart. Samples shall then be stretched until the marks are nine (9) inches apart before breaking.

22. The tensile strength of the rubber insulation, as shown by tests made on a carefully prepared sample, shall be not less than one thousand (1,000) lbs. per square inch. The sample, for five (5) minutes before and, as near as practicable, during the test, shall be maintained at a temperature of seventy (70) degrees Fahrenheit.

23. The specific gravity of the rubber insulation shall not be less than 1.75.

Chemical tests of rubber insulation.

24. The insulation shall show on analysis not less than thirty (30) nor more than thirty-three (33) per cent. of pure Upriver, fine, dry, Para rubber, of best quality; not more than four (4) per cent. of solid waxy hydrocarbons, consisting of refined paraffine or pure ozokerite; not more than 0.7 per cent. of free sulphur; not more than 2.5 per cent. total sulphur, freedom from all foreign matter, and the mineral matter shall be such as will not have a deleterious effect on the insulation.

Electrical tests of rubber insulation.

25. The thickness of the rubber insulation around each conductor (measured at the thinnest point), the minimum insulation resistance in

megohms per mile when corrected to the standard temperature of 60 degrees Fahrenheit, and the dielectric strength shall conform to the following requirements:

B. & S. Gage.	Thickness of Insulation.	Insulation Resistance Megohms Per Mile.	Test Voltage Alternating Current.
0	1/8 inch.	900	10,000
1	1/8 "	1,100	10,000
2	1/8 "	1,200	10,000
4	3-32 "	1,100	9,000
6	3-32 "	1,300	9,000
8	3-32 "	1,600	9,000
9	5-64 "	1,500	7,000
10	5-64 "	1,600	7,000
12	5-64 "	1,900	7,000
14	5-64 "	2,100	7,000
16	1-16 "	2,100	4,000

26. The test for insulation resistance must be made upon all wire after at least twelve (12) hours' submersion in water and while still immersed results be corrected to a water temperature of sixty (60) degrees Fahrenheit. Tests must be made with the wire in coils, suitable for examination and before the application of tape or other covering with a well insulated battery and galvanometer, with not less than one hundred (100) volts and readings must be taken after one minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

27. The cable when made up after assembling with lead covering and armoring shall have the test voltage applied for five (5) minutes to each conductor as follows:

28. Between conductors apply the full voltage tests as required for separate wires.

29. Between each conductor and lead sheath apply a test voltage of but 60 per cent. of that required for separate wires.

30. The insulation resistance of each conductor shall be measured after test voltage has been applied to the completed cable and the resistance found shall be not less than that specified for separate conductors.

Inspection.

31. The manufacturer shall notify the purchaser when the manufacture of the wire and cable is to begin in order that inspection may be arranged for.

Reels.

32. Each cable shall be placed on a separate reel holding the full length of cable. Both ends of cable must be accessible for testing but be covered and protected from injury. The flanges of the reel shall be large

enough to protect the cable in handling and rolling. The reels will become the property of the purchaser, but must be taken back by the manufacturer upon the request of the purchaser.

Marking.

33. Each reel shall have the weight, length, number of conductors in cable, the name of maker and purchaser's order or inspection number plainly and indelibly marked on a strong tag securely fastened to the cable and also stenciled on the outside of the reel.

Notification.

34. The completed cable is not to be shipped from place of manufacture until permission in writing has been received from the purchaser. Should the cable on arrival at destination be found defective and not up to the specification requirements, it will be returned to the manufacturer, who must pay all freight charges.

CONCLUSION.

That the Specification for Mineral Matter Rubber Compound, Insulated, Lead Covered, Armored Submarine Cable for 660 or Lower Voltage Service be adopted by the Association and printed in the Manual, as its requirements are in accordance with the best practice, and, as far as applicable, are the same as those for rubber insulated wire given above.

DOUBLE-BRAIDED, WEATHERPROOF, HARD-DRAWN, COPPER LINE WIRE.

General description.

1. The intention of this specification is to provide for the furnishing of hard-drawn copper line wire, which is covered with a double thickness of weatherproof braiding.

Conductor.

2. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil must contain no weld, joint or splice.

Properties.

3. The mechanical and electrial properties of the finished wire must be in accord with the following requirements:

B. & S. Gage.	Diameter in Mills.	Breaking Strength, Pounds.	Per Cent. Elongation in 10 Inches.	Conductivity per Cent. of Pure Copper.
6	162	1,210	1.12	97
7	144	970	1.08	97
8	128	779	1.06	97
9	114	620	1.04	97
10	102	502	1.02	97
12	81	319	1.00	97

Covering.

4. The conductor shall be covered with two (2) closely-woven braids of cotton, each of which shall not be less than one-thirty-second ($\frac{1}{32}$) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

5. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit, or such as will soften the wire more than is allowable with the elastic limit required. The wire must remain in the compound and must be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

6. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of one hundred and twenty-five (125) degrees Fahrenheit, and shall not crack when the finished wire is subjected to a temperature of ten (10) degrees below zero, Fahrenheit.

7. The qualities of the compound and the method of application shall be such as not to injure the braided covering or the wire.

8. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean, white, glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed in sufficient amount to form a ridge perceptible to the fingers, or in case the compound is absorbed by the paper, as indicated by a greasy or oily spot.

9. The finished wire shall be immersed in a freezing mixture, which shall show a temperature of ten (10) degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in its surface, the wire shall be rejected.

Inspection and tests.

10. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

11. The manufacturer must provide at the mill all apparatus and labor for making the required tests under the supervision of the purchaser.

12. Tests shall be made at the mill or on samples submitted by the manufacturer and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

13. If, upon arrival at destination the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who must pay all freight charges.

Packing for shipment.

14. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive	One-fourth mile
6 to 8, inclusive	One-third mile
9 to 12, inclusive	One-half mile

15. The diameter of the eye of the coil shall be not less than twenty (20) inches nor more than twenty-two (22) inches.

16. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

17. Each coil shall have the weight, length and size of wire, the name of maker, the purchaser's order and inspection number and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

*CONCLUSION.

That the Specifications for Double-Braided, Weatherproof, Hard-Drawn Copper Line Wire, presented as prescribing the best practice, be adopted by the Association and printed in the Manual.

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*See amendment, page 139.

*DOUBLE-BRAIDED, WEATHERPROOF, GALVANIZED "B" IRON LINE WIRE.

General description.

1. The intention of this specification is to provide for the furnishing of galvanized B. B. iron line wire which is covered with a double thickness of weatherproof braiding.

Conductor.

2. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil must contain no weld, joint or splice.

3. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness and so applied that it adheres firmly to the iron and presents a smooth surface.

Properties.

4. The mechanical and electrical properties of the finished wire must be in accord with the following requirements:

B. W. Gage.	Diameter in Mills.	Breaking Strength, Pounds.	Per Cent. Elongation in 10 Inches.	Resistance Ohms per Mile at 68 Degrees F.
6	203	1,652	15	9.49
8	165	1,092	15	14.36
10	134	722	12	21.71
12	109	476	12	32.94

Test of galvanizing.

5. A sufficient number of samples shall be taken from the wire submitted for inspection and shall be tested, these pieces being not less than eight (8) inches long, and not more than seven (7) pieces of wire shall be immersed in the specified quantity of solution.

6. The samples shall be cleaned before being tested, first with carbona, benzine or turpentine and cotton waste, and then thoroughly rinsed in clear water and wiped dry with clean cotton waste. The samples shall be cleaned and dried before being immersed in the solution. The samples, when placed in the solution, shall be well separated to permit the solution to act uniformly on all immersed portions of the samples.

7. The samples shall be tested in a neutral solution of commercial copper sulphate having a specific gravity of 1.186 at a temperature of 65 degrees F. The solution shall be neutralized by the addition of excess of chemically pure cupric oxide (Cu O) which will collect in the bottom of the containing vessel. The solution shall be filtered before being used. Not less than four (4) ounces of fresh solution shall be used for each test of seven (7) wires. The solution must be maintained at a temperature between 62 and 68 degrees F. during the test. The samples shall be immersed in the solution to a depth of four (4) inches.

8. The samples shall be immersed in the solution for one (1) minute, shall then be washed in clean water having a temperature of between 62

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*See amendment, page 130.

and 68 degrees F. and be wiped dry with clean cotton waste. This operation shall be performed four (4) times.

9. If there is a bright metallic copper deposit on the samples after the fourth immersion, the wire represented by the samples shall be rejected, but copper deposited on zinc or within one (1) inch of the end of the sample shall not be considered as cause for rejection.

10. In case of a failure of one (1) wire in the group of seven (7) being tested together, or if there is reasonable doubt as to the copper deposit, two (2) check tests shall be made of samples from the same coil, but unless the two (2) check tests are satisfactory the wire shall be rejected.

Covering.

11. The conductor shall be covered with two (2) closely-woven braids of cotton, each of which shall not be less than one-thirty-second ($\frac{1}{32}$) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

12. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit or such as will soften the wire more than is allowable with the elongation required. The wire must remain in the compound long enough to drive out all moisture in the covering and must be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

13. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of one hundred and twenty-five (125) degrees Fahrenheit and shall not crack when the finished wire is subjected to a temperature of ten (10) degrees below zero Fahrenheit.

14. The qualities of the compound used and the method of application shall be such as not to injure the braided covering of the wire.

15. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean, white, glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed in sufficient amount to form a ridge perceptible to the fingers or in case the compound is absorbed by the paper, as indicated by a greasy or oily spot.

16. The finished wire shall be immersed in a freezing mixture which shall show a temperature of ten (10) degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in its surface, the wire shall be rejected.

Inspection and tests.

17. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

18. The manufacturer must provide at the mill all apparatus and labor for making the required tests, under the supervision of the purchaser.

19. Tests shall be made at the mill or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

20. If, upon arrival at destination, the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for shipment.

21. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive ....One-fourth mile
6 to 8, inclusive ....One-third mile
9 to 12, inclusive ....One-half mile

22. The diameter of the eye of the coil shall be not less than twenty (20) inches nor more than twenty-two (22) inches.

23. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

24. Each coil shall have the weight, length and size of wire, the name of the maker, the purchaser's order and inspection number and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

*CONCLUSION.

That the Specification for Double-Braided, Weatherproof, Galvanized B. B. Iron Line Wire be adopted by the Association and printed in the Manual as conforming to the requirements of the Specification for Weatherproof, Hard-Drawn Copper Line Wire where applicable.

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*See amendment, page 130.

DOUBLE-BRAIDED, WEATHERPROOF, HARD-DRAWN, COPPER-CLAD, STEEL LINE WIRE.

General description.

1. The intention of this specification is to provide for the furnishing of copper-clad, steel line wire which is covered with a double thickness of weatherproof braiding.

Conductor.

2. The wire shall be composed of a steel core with a copper coat permanently welded thereto. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil must contain no weld, joint or splice.

Properties.

3. The mechanical and electrical properties of the finished wire must be in accord with the following requirements:

B. & S. Gage.	Diameter in Mills.	Breaking Strength, Pounds.	Conductivity Per Cent. of Pure Copper at 60 Deg. F.
6	162	1,700	35
7	144	1,450	35
8	128	1,150	35
9	114	950	35
10	102	760	35
12	81	490	35

4. The wire, when broken by twisting, repeated bending, or when heated to a dull red and quenched in water at 32 degrees F., shall show no separation of the copper from the steel.

5. Should the breaking weight of the coil be less than that specified, tests of two (2) additional samples shall be made from the same coil and the average of the three (3) tests shall determine the acceptance or rejection of the coil.

6. Should the conductivity of a sample of a coil be lower than that specified, pieces may be cut from each end until samples are obtained having the required conductivity.

Covering.

7. The conductor shall be covered with two (2) closely-woven braids of cotton, each of which shall not be less than one-thirty-second ($\frac{1}{32}$) inch in thickness. This braiding shall be thoroughly saturated with a permanent weatherproofing compound, which shall be applied in sufficient quantity to fill all interstices and form a continuous coating over the covering.

8. The temperature of the saturating compound shall not be more than 300 degrees Fahrenheit, or such as will soften the wire more than is

allowable with the elongation required. The wire must remain in the compound long enough to drive out all moisture in the covering, and must be closely stripped so that there shall not be any excess of compound beyond what is absorbed by the cotton and the filling of the interstices of the same, leaving a good, smooth surface.

9. The compound shall be insoluble in water, shall not melt when the finished wire is subjected to a temperature of one hundred and twenty-five (125) degrees Fahrenheit and shall not crack when the finished wire is subjected to a temperature of ten (10) degrees below zero Fahrenheit.

10. The qualities of the compound used and the method of application shall be such as not to injure the braided covering of the wire.

11. The melting and freezing tests of the compound shall be made as follows:

Short pieces of wire shall be placed on a piece of clean, white, glazed paper in a chamber which has been heated to 125 degrees Fahrenheit, this temperature to be maintained for half an hour. The wire shall be rejected if the compound becomes sufficiently fluid to be transferred to the paper on which the wire was placed, in sufficient amount to form a ridge perceptible to the fingers or in case the compound is absorbed by the paper, as indicated by a greasy or oily spot.

12. The finished wire shall be immersed in a freezing mixture which shall show a temperature of ten (10) degrees below zero Fahrenheit for one-half (½) hour, and if, upon removal, the compound so contracts (without bending sample) as to produce cracks in the surface, the wire shall be rejected.

Inspection and tests.

13. The purchaser is to have the right to make such inspection and tests as he may desire of the materials and of the wire at any stage of the manufacture.

14. The manufacturer must provide at the mill all apparatus and labor for making the required tests, under the supervision of the purchaser.

15. Tests shall be made at the mill or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination. The wire may be inspected before and after it has been covered.

16. If, upon arrival at destination, the wire does not meet the requirements of this specification, it will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for shipment.

17. The wire shall be furnished in coils of not less than the following lengths:

0 to 4, inclusive	One-fourth mile
6 to 8, inclusive	One-third mile
9 to 12, inclusive	One-half mile

18. The diameter of the eye of the coil shall be not less than twenty (20) inches nor more than twenty-two (22) inches.

19. Each coil shall be securely bound with a layer of heavy wrapping paper and with an outside wrapping of burlap, with each turn of burlap overlapping the other one-half (½) its width.

20. Each coil shall have the weight, length and size of wire, name of maker, the purchaser's order and inspection number, and the proper shipping address plainly and indelibly marked on two (2) strong tags. One of these tags shall be attached to the coil inside the burlap and the other shall be attached to the coil outside the burlap.

CONCLUSION.

That the Specification for Double-Braided, Weatherproof, Hard-Drawn, Copper-Clad, Steel Line Wire, prepared in the same general form and presenting the same requirements as the Specification for Copper Line Wire and for B. B. Iron Line Wire, be adopted by the Association and printed in the Manual.

*SPECIFICATION FOR GALVANIZED E. B. B. IRON BOND WIRES.

General description.

1. The intention of this specification is to provide for the furnishing of No. 8 B. W. G. galvanized E. B. B. iron wires for binding rail joints of steam railroads where electric track circuits are to be used.

Conductor.

2. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. The wires shall be cut and straightened to the length specified on order. The ends shall be sheared cut and free from burrs.

3. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness and so applied that it adheres firmly to the iron and presents a smooth surface.

Properties.

4. The mechanical and electrical properties of the finished wire must be in accord with the following requirements:

B. W. G.	Diameter in Mills.	Breaking Resistance, Pounds.	Per Cent. Elongation in 10 Inches.	Resistance Ohms Per Mile at 68 Deg. F.
8	165	975	15	12.05

The wire shall not vary more than three (3) mills from the normal diameter.

Test of galvanizing.

5. A sufficient number of samples shall be taken from the wire submitted for inspection and shall be tested, these pieces being not less than eight (8) inches long and not more than seven (7) pieces of wire shall be immersed in the specified quantity of solution.

6. The samples shall be cleaned before being tested, first with carbona, benzine or turpentine and cotton waste, and then thoroughly rinsed in clean water and wiped dry with clean cotton waste. The samples shall be cleaned and dried before being immersed in the solution. The samples, when placed in the solution, shall be well separated to permit the solution to act uniformly on all immersed portions of the samples.

7. The samples shall be tested in a neutral solution of commercial copper sulphate having a specific gravity of 1.186 at a temperature of 65 degrees F. The solution shall be neutralized by the addition of excess of chemically pure cupric oxide (Cu O) which will collect in the bottom of the containing vessel. The solution shall be filtered before being used. Not less than four (4) ounces of fresh solution shall be used for each test of seven (7) wires. The solution must be maintained at a temperature between 62 and 68 degrees F. during the test. The samples shall be immersed in the solution to a depth of four (4) in.

8. The samples shall be immersed in the solution for one minute, shall then be washed in clean water having a temperature of between 62 and 68 degrees F. and be wiped dry with clean cotton waste. This operation shall be performed four (4) times.

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*See amendment, page 130.

9. If there is a bright metallic copper deposit on the samples after the fourth immersion, the wire represented by the samples shall be rejected, but copper deposited on zinc or within one (1) in. of the end of the sample shall not be considered as cause for rejection.

10. In case of a failure of one (1) wire in the group of seven (7) wires being tested together, or if there is reasonable doubt as to the copper deposit, two (2) check tests shall be made of samples from the same bundle, but unless the two (2) check tests are satisfactory, the wire shall be rejected.

Inspection and tests.

11. The purchaser is to have the right to make such inspection and tests as he may desire of the wire at any stage of the manufacture.

12. The manufacturer must provide, at the mill, all apparatus and labor for making the required tests, under the supervision of the purchaser.

13. Tests shall be made at the mill on the wire before it is cut into lengths, or on samples submitted by the manufacturer, and may also be made on the wire upon its arrival at destination.

14. If, upon arrival at destination, the wires do not meet the requirements of this specification, they will be rejected and returned to the manufacturer, who shall pay all freight charges.

Packing for shipment.

15. The wire shall be put up in bundles of one hundred (100) or three hundred (300), as ordered, well burlapped at ends and securely fastened in not less than three (3) places.

Tagging.

16. A tag shall be securely fastened to each bundle, having plainly and indelibly marked thereon the number of and length of the wires, the purchaser's order and inspection number and the proper shipping address.

*CONCLUSION.

That the Specification for Galvanized E. B. B. Iron Bond Wires, which calls for the best practice in the furnishing of this product, be adopted by the Association and printed in the Manual.

In the manufacture of cables where the conductors are composed of a number of wires, it is necessary that the wires or strands be of a proper size to give a perfect lay for each conductor, as wires of exact B. & S. gage size will not always give a perfect lay, and there has been developed in the trade various sizes of strands of wires which are standard in the manufacture of stranded and flexible conductors. These special standard sizes of strands are not given or referred to in catalogues intended for a purchaser's use, but should a cable be ordered with conductors of a size requiring strands of other sizes than the manufacturer's standard, a higher price is charged and longer time required in the making of the cable, owing to the special strands that have to be procured. It is, therefore, advisable that, when ordering cables with flexible conductors, these should conform

*See amendment, page 130.

to the requirements of the following tables, which differ only in the sizes of the strands used and, therefore, in the flexibility of the conductors.

CONCLUSION.

That the stranding table given on page 156 of Volume 10, Part 1, of 1909 Proceedings, be changed and the following tables for stranded conductors and for flexible conductors be adopted by the Association and printed in the Manual:

STRANDED CONDUCTORS.

Approximate Size, B. & S. Gage.	Number of Strands.	Actual Circular Mills.
2000000	127	2000250
1500000	91	1502592
1000000	91	1003275
900000	91	900900
800000	91	804076
700000	61	698389
600000	61	597861
500000	37	506493
400000	37	400192
350000	37	351722
300000	37	299700
250000	37	248788
0000	19	211470
000	19	167884
00	19	132468
0	19	105450
1	19	84018
2	19	66139
3	7	52274
4	7	41503
5	7	33327
6	7	26047
8	7	16464
9	7	12943
10	7	10374
12	7	6300
14	7	4375
16	7	2527
18-7 No. 26	7	1778
20-7 No. 28	7	1113
21-7 No. 29	7	889
22-7 No. 30	7	700

FLEXIBLE CONDUCTORS.

Approximate Size, B. & S. Gage.	Number of Strands.	Actual Circular Mills.
0000	37	210900
000	37	168572
00	37	133200
0	37	105894
1	37	83472
2	37	66822
3	19	52364
4	19	41971
5	19	33516
6	19	26011
8	19	17011
9	19	12844
10	19	10051
12	19	6498
14	19	3990
16	19	2508
18-7 No. 26	19	1501

Your Committee finds it desirable that a standard form of report on which the results of physical and electrical tests of wire and insulation may be shown, should be used, and recommend that the Association adopt the form which is herewith presented.

(Size of Sheet—8½"x13⅞")

WIRE INSPECTION REPORT No........

..............................191....

Manufacturer ....
Location of factory........................Reqn. No..................
Whose order ....Order No................

GENERAL DESCRIPTION.

Test of..
To be located at.........................Working voltage...........
Single conductor: Length....ft. Size....B. & S. Wall....in. Reels....
Length....ft. Armor....B. & S. Lead sheath....in. Reels......

Composition.

No. of Cond. Size, B. & S. No. of Strands. Size of Strands. Wall. Cable.
....
....
....

SPECIFICATION REQUIREMENTS.

Voltage....volts A. C. for...min. Insulation resistance....megs. per mile at 60 deg. F.
Tensile strength of insulation....lbs. per sq. in. Tensile strength of copper......lbs. per sq. in.
Permanent set of insulation, 20%. Conductivity, 98% at 60 deg. F.
Elongation of insulation, 350%. Pure Para rubber, 30%.

PHYSICAL TESTS.

Conductor.	Insulation.
Elongation.....% in........inches	Elongation......% in........inches
Torsion.....twists in........inches	Permanent set..% in........inches
Tensile strength....lbs. per sq. in.	Tensile strength....lbs. per sq. in.

CHEMICAL TESTS.

Conductor tinning test: Immersed.............times before blackening
Insulation—Pure Para rubber..%. Sulphur..%. Dry mineral matter..%

BRAIDING TESTS.

Gain....% of weight of braid after....hours. Immersion at....deg. F.

ELECTRICAL TESTS.

1. Voltage test: Unbraided wire tested....volts A. C. for..........Min.
Remarks ....
2. Conductivity test............% of Matthiessen's standard at 60 deg. F.
3. Insulation resistance test: Temperature.... deg. F. Constant....Megs.
Time immersed.............Hrs. Voltage of cells volts...........
Coil Nos. Length. Defls. Meg. Mile. Coil Nos. Length. Defls. Meg. Mile:
....
....
....

.........................Inspector.

CONCLUSION.

That the Wire Inspection Sheet presented be adopted by the Association and printed in the Manual.

Subject No. 2.—Uniform signal system.

On account of the difference of opinion in the Committee, its report on this subject was, by vote of the Association, referred back to it in March, 1910, with instructions to confer with the proper Committee of the American Railway Association. Such conference was held June 8, as outlined above. A Sub-Committee of three was appointed by the Committee on Transportation to further report to the entire Committee, it being understood that their conclusions, when arrived at, would be transmitted to us. To date we have received no word from them, as they are carefully considering the subject.

We, therefore, report progress.

Subject No. 3.

The Committee reports progress. (The Railway Signal Association has this year practically completed the Specification for Mechanical Interlocking, including wrought-iron pipe, which is shown in Volume 7 of its Journal for 1910, and the Committee will arrange to report complete specifications at the annual meeting in 1912.)

Subject No. 4.

The Committee reports progress. (The Railway Signal Association has this year practically completed Specification for Electric Interlocking, which is shown in Volume 7 of its Journal for 1910, and the Committee will arrange to report complete specifications at the annual meeting in 1912.)

Subject No. 5.

No meetings were held, as the Chairman of the Committee on Ties advised that that Committee would not take up the subject this year, and the Committee on Wood Preservation did not invite the Sub-Committee to confer with it.

Subject No. 6.

Conference with Committee on Yards and Terminals.

A conference was held as stated above.

Special conference with Committee on Track.

Conferences were held as outlined above, but the entire Committee has had no opportunity to pass upon this important subject. We, therefore, recommend that, if any matters of switch point drilling, spacing of ties, insulation, etc., require consideration after the annual meeting, they be the subject of joint action by Committees V and X.

Subject No. 7.

We recommend that the subject covered in report of conference with Committee on Track be the only additional one assigned to this Committee next year.

Respectfully submitted,

A. H. Rudd (*Director*), Signal Engineer, Pennsylvania Railroad, Philadelphia, Pa., *Chairman.*

L. R. Clausen, Superintendent, Chicago, Milwaukee & St. Paul Railway, Chicago, Ill., *Vice-Chairman.*

Azel Ames, United States Train Control Board, New York, N. Y.

C. C. Anthony, Assistant Signal Engineer, Pennsylvania Railroad, Philadelphia, Pa.

H. Baker, General Manager, Queen & Crescent Route, Cincinnati, Ohio.

H. S. Balliet, Engineer Maintenance of Way and Signal Engineer, Electric Division, Grand Central Terminal, New York Central & Hudson River Railroad, New York, N. Y.

W. G. Besler, Vice-President and General Manager, Central Railroad of New Jersey, New York, N. Y.

W. B. Causey, Superintendent, Chicago Great Western Railroad, Chicago, Ill.

C. A. Christofferson, Signal Engineer, Northern Pacific Railway, St. Paul, Minn.

C. E. Denney, Signal Engineer, Lake Shore & Michigan Southern Railway, Cleveland, Ohio.

W. J. Eck, Electrical Engineer, Southern Railway, Washington, D. C.

W. H. Elliott, Signal Engineer, New York Central & Hudson River Railroad, Albany, N. Y.

W. J. Harahan, Vice-President, Erie Railroad, New York, N. Y.

M. H. Hovey, Wisconsin Railway Commission, Madison, Wis.

A. S. Ingalls, Assistant General Superintendent, Lake Shore & Michigan Southern Railway, Cleveland, Ohio.

J. C. Mock, Electrical Engineer, Detroit River Tunnel Company, Detroit, Mich.

F. P. Patenall, Signal Engineer, Baltimore & Ohio Railroad, Baltimore, Md.

J. A. Peabody, Signal Engineer, Chicago & Northwestern Railway, Chicago, Ill.

Frank Rhea, Engineer for Signal Department, General Electric Company, Schenectady, N. Y.

W. B. Scott, Assistant Director Maintenance and Operation, Harriman Lines, Chicago, Ill.

Thos. S. Stevens, Signal Engineer, Santa Fe System, Topeka, Kan.

H. H. Temple, Superintendent, Baltimore & Ohio Railroad, New Castle, Pa.

Edwin F. Wendt (*Director*), Assistant Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa.

J. C. Young, Signal Engineer, Union Pacific Railroad, Omaha, Neb.

Committee.

AMENDMENTS.

Amend Clause 12, of the Specification for "Mineral Matter Rubber Compound, Insulated, Lead-Covered, Armored Submarine Cable for 660 or Lower Voltage Service," to read as follows:

"12. Over the armoring a layer of twisted jute roving shall be placed at least one-sixteenth (1/16) inch thick, saturated with a black insulating weatherproof compound that shall be neither injuriously affected by nor have an injurious effect upon the braid at 200 degrees Fahrenheit."

Amend the conclusion relating to "Specifications for Double-Braided, Weatherproof, Hard-Drawn Copper Line Wire" to read as follows:

"That the Specifications for Double-Braided, Weatherproof, Hard-Drawn Copper Line Wire be adopted by the Association and printed in the Manual."

Amend the conclusion under the "Specification for Double-Braided, Weatherproof, Galvanized B.B. Iron Line Wire" to read as follows:

"That the Specification for Double-Braided, Weatherproof, Galvanized B.B. Line Wire be adopted by the Association and printed in the Manual as conforming to the requirements of the Specification for Weatherproof, Hard-Drawn Copper Line Wire where applicable."

Amend the title of the Specification to read as follows:

"Specification for Double-Braided, Weatherproof, Galvanized B.B. Line Wire."

Amend the conclusion relating to "Specification for Galvanized E.BB. Iron Bond Wires" to read as follows:

"That the Specification for Galvanized E.BB. Bond Wires be adopted by the Association and printed in the Manual."

Amend the title of the Specification to read as follows:

"Specification for Galvanized E.BB. Bond Wires."

DISCUSSION.

(The report of the Committee on Signals and Interlocking was presented by Mr. W. H. Elliott, Signal Engineer, New York Central & Hudson River Railroad, a member of the Committee, in the absence of the Chairman and Vice-Chairman.)

The President:—The conclusions of the Committee are found, beginning on page 121 of the Bulletin. The first conclusion is: "That the revised Specifications for Mineral Matter Rubber Compound Insulated Signal Wire be adopted by the Association and printed in the Manual." These specifications are before the convention for discussion. The Committee desires that each specification be taken up separately. If you will turn to page 124, you will find the Revised Specification for Mineral Matter Rubber Compound Insulated Signal Wire for Current of 660 Volts or less. If there are no objections to these specifications, as read by the heading, they will be adopted as submitted.

The next specification is: "Specification for Mineral Matter Rubber Compound Insulated Aerial Braided Cables for Current of 660 Volts or less." This specification is before the convention for discussion. This is an interesting subject. These specifications have been passed by the Railway Signal Association, and thoroughly discussed and approved by that association. If there is no objection to these specifications, as submitted, they will be approved.

The next specification is for "Mineral Matter Rubber Compound, Insulated, Lead Covered, Armored Submarine Cable for 660 or Lower Voltage Service." These specifications are before the convention for discussion.

Mr. Azel Ames (United States Block Signal and Train Control Board):—There is a misprint in clause 12, on page 14, in describing the covering to be placed over the armoring on submarine cables. It says: "Over the armoring a layer of closely woven jute braiding shall be placed," etc. It should read: "Over the armoring a layer of twisted jute roving shall be placed," etc.

The President:—If there is no further discussion on this specification, it will be passed as submitted by the Committee.

The next specification is for "Double-braided, Weatherproof, Hard-Drawn, Copper Line Wire."

Mr. B. H. Mann (Missouri Pacific):—The question of language in the conclusions as recommended by the Committee is important. The specification is to be adopted as being in accordance with the best practice. The mere fact that it is to be put in the Manual might imply that it is the best practice. There is a doubt as to whether the Committee means that the double-braided, weatherproof, hard-drawn copper line wire is the best sort of weatherproofing, or whether this will be specified as the best practice for the use of double-braided wire. As far as the question of whether the double-braided insulation is better than a triple-braided insulation or some other sort of insulation, it does not seem to me that this is the time to take that up, and as far as the adoption of the specification by the Railway Signal Association is concerned, it was put through just as has been the first conclusion we have adopted, leaving out the words "presented as prescribing the best practice." By so doing we will avoid the possibility of inferring that the double-braided weatherproof wire is the best for insulation.

Mr. W. H. Elliott:—The Committee has no objection to accepting the suggestion made by Mr. Mann.

Mr. Mann:—You should leave it optional with any railroad to use a triple-braided covering, if they desire.

The President:—The Committee accepts that amendment, and if there is no objection, it will be approved.

The next specification is that for "Double-Braided Weatherproof Galvanized 'B' Iron Line Wire."

Mr. W. H. Elliott:—The Committee asks to eliminate the word "Iron," both in the title of the specification and in the second line, as the revised title, "Double-Braided, Weatherproof, Galvanized BB Line Wire," more correctly specifies the material which is furnished and used.

Mr. Mann:—I will ask the Committee's indulgence as to what is meant by the conclusion as to the use of the BB line wire. Is it understood the Committee submits for adoption the use of BB weatherproof line wire as the best practice, or is this merely a specification for BB iron line wire?

Mr. W. H. Elliott:—The two things which I understand Mr. Mann to speak of are in regard to the use of the word "iron," and if the B wire is to be preferred to the extra BB. The Committee have drawn up a specification for BB line wire, as that was the quality of wire most generally used. Another specification would be drawn for extra BB line wire, if it is desired to have such a specification. The specification in its revised form, eliminating the word "iron," covers the material as furnished and procured commercially, and in order to prevent any confusion or difference between the purchaser and the manufacturer, the word "iron" is to be eliminated.

Mr. Mann:—I would ask if the Committee would insert the same words that they have in another conclusion, viz.: "for this product." In this other conclusion they have brought this thought out clearly.

The President:—The Committee states that has been eliminated from the other conclusions. Where do you find that?

Mr. Mann:—I am looking ahead to the next one, page 145.

The President:—That is a little bit out of order. If there is no further discussion on the specification under consideration, it will stand approved, and we will pass to the next, "Double-Braided, Weatherproof, Hard-Drawn Copper-Clad Steel Line Wire."

Mr. W. H. Elliott:—The Committee asks permission to eliminate from the second line of the conclusion the words: "which calls for the best practice in the furnishing of this product." This is in order to meet Mr. Mann's suggestion. The Committee also asks to eliminate the word "iron," both in the title of this specification and in the first line of the conclusion," as the revised title, "Galvanized E.B.B. bond wires" correctly specifies the material which is furnished and used for bond wires.

The President:—If there is no objection to this specification as submitted, it will stand approved, and we will turn to the conclusion on page 145: "That the Specification for Galvanized E.B.B. Iron Bond Wires which calls for the best practice in the furnishing of this product, be adopted by the Association and printed in the Manual." If there is no discussion, the specifications will be accepted as submitted, and the conclusion on page 145 will be changed as suggested by the Committee.

The next conclusion is the table for Stranded Conductors. If there is no objection, the conclusion will be adopted.

On page 149 there is a conclusion, reading as follows: "That the wire inspection sheet presented be apodted by the Association, and printed in the Manual." Any discussion on the wire inspection report? If there is no objection, the conclusion of the Committee will be adopted. That finishes the work of the Committee. Are there any suggestions to the Committee, or any further discussion on the Committee's report?

Mr. J. M. Meade (Santa Fe):—As there are only two members out of 1,000 have ventured on this occasion to say anything, I move that the report be accepted as revised.

(Motion seconded.)

Mr. C. H. Ewing (Atlantic City Railroad):—I would like to call attention to subject 2. As I understand it, the subject of uniform signaling practice is in about the same condition as at the last meeting, with the exception that it has been referred to the American Railway Association Committee. It would be of very particular interest to know if the Committee have had any meetings on this subject, and if they have been able to reconcile any of their differences.

Mr. W. H. Elliott:—The Committee met in conference with the Transportation Committee of the American Railway Association at Niagara Falls last June, and a full discussion of the subject of signal indications was had. I understand the Committee of the American Railway Association have about concluded their work and expect to give a decision in the near future. At this time we have not had any word as to what their decision will be, and until it is received this Committee does not expect to take any further action on the subject.

The President:—Is there any further discussion on this report? If not, the Committee will be dismissed, with the thanks of the Association.

REPORT OF COMMITTEE XVIII.—ON ELECTRICITY.

(Bulletin 130.

To the Members of the American Railway Engineering and Maintenance of Way Association:

RESUME OF PREVIOUS WORK.

Substitution of electricity for steam as a means of propulsion made such strides in the last few years that on March 16, 1908, the Board of Direction of the Association in pursuance with numerous requests made on it passed a resolution directing its President to appoint a Special Committee to treat the subject and pass upon its various phases. In accordance with this resolution, Mr. Berg, then President of the Association, named the following gentlemen:

George W. Kittredge, Chairman;
J. B. Austin, Jr.,
F. A. Bagg,
R. D. Coombs,
E. P. Dawley,
W. W. Drinker,
G. A. Harwood,
C. E. Lindsay,
H. R. Talcott,

and addressed this letter to the Committee on April 24, 1908:

"In accordance with resolution adopted by the Board of Direction of the American Railway Engineering and Maintenance of Way Association on March 16, 1908, for the appointment by the President of a Special Advisory Committee to report direct to the Board of Direction on the necessity for and advisability of establishing a standing committee of the Association to consider and report on special questions connected with the electrified sections of steam railroad systems, I hereby appoint you on such Special Advisory Committee and will ask Mr. Kittredge to act as Chairman.

"The work of the Special Committee will be only advisory to the Board of Direction and, so to say, confidential in the nature of preliminary expert advice to assist the Board in reaching its decision.

"The Special Committee should aim particularly to take a broad view of the question as affecting the Association as a whole and the interests represented by the entire body of members, as also the possible comment that such a step, unless carefully considered and defined, might produce in the minds of many of our valued members and the steam railroad world.

"The mere fact that certain steam railroad systems have electrified sections of their roads and that a limited number of our members, being in close and daily touch with the new conditions, feel the necessity for joint study of certain conditions, should not be considered as the main controlling factor in determining the necessity and desirability of the appointment of such a Standing Committee.

"Similarly, the Special Committee should give careful consideration to the question of not allowing our Association to overstep the limits of its legitimate field of work.

"My individual view is that, if the Standing Committee is appointed, its work should be limited to investigating and reporting on the special characteristic requirements and new conditions in the design, construction and maintenance of track and transmission structures of steam railroad systems operating electric equipment on certain sections of their road.

"It is suggested that the Special Committee, in addition to discussing the general questions of the necessity for and the desirability of appointing such a Standing Committee, should outline the scope of the work for such a Standing Committee, with mention of typical cases or subjects so as to illustrate their views by concrete examples.

"The Special Committee should also consider whether the appointment of such a Standing Committee might not preferably be postponed for one or more years, even if they are convinced that eventually such action will become imperative. On the other hand, the appointment at an early date might be considered largely as educational and to give the Standing Committee time to find itself.

"Finally, it is desirable for the Special Committee to make a recommendation as to a distinctive short name for the Standing Committee, if appointed, as also a brief outline of its scope of work and subjects for consideration, suitable for publication as the instructions for the guidance of the Standing Committee, if appointed.

"Under the resolution referred to above, the Board specified on or before December 31, 1908, as the date for the Special Advisory Committee to report to the Board. I call attention that the Board now expects to hold a meeting on November 17, 1908, in Chicago, at which the report of the Special Committee could be considered if presented before that date.

"I will be glad to hear from you whether you will accept the appointment on this Special Advisory Committee, and on receipt of answers will advise Mr. Kittredge accordingly, and request him to take such further action as he may think proper in regard to calling the Committee together."

After considerable preliminary correspondence the Special Advisory Committee held a meeting in Mr. Kittredge's office on November 10, 1908, at which were present:

George W. Kittredge, Chairman;
J. B. Austin, Jr.,
F. A. Bagg,
R. D. Coombs,
E. P. Dawley,
G. A. Harwood,
H. R. Talcott.

At this meeting the following resolutions were passed:

(1) That it is the sense of this Committee that a standing committee on "Electricity" be recommended to the Board, the appointment of such a Committee to be made forthwith.

(2) That the scope of the work cover electric traction and transmission as affecting the design, construction, maintenance and operation of railways.

(3) Some of the concrete examples which should come up for discussion within the limits of this scope are:

Transmission line crossings,
Clearances,
Insulation and protection,
Electrolysis,
Relation to track structures,
Maintenance organization.

These are given as a partial list only and are not intended to cover all.

The name "Electricity" is recommended for such standing committee, it being the most comprehensive name suggested and being short and a proper one in view of its being a Committee of the American Railway Engineering and Maintenance of Way Association, limited by the scope of the Committee as outlined above.

The Committee feels that it has fulfilled its requirements and asks to be discharged.

The action taken by the Association in connection with the report is found in the following letter from its Secretary, dated November 25, 1908:

"I beg to inform you that the report of your Special Committee on the necessity for and advisability of appointing a standing committee to consider questions in connection with electrified sections of steam railroads was presented to the Board of Direction at a meeting held in Chicago, November 17, 1908. The report was accepted as a whole, the thanks of the Board of Direction extended to the Committee, and the Committee discharged.

"In accordance with the first recommendation of your Special Committee, that a standing committee on 'Electricity' be appointed forthwith, the Board of Direction has instructed me to inform you of your appointment on the Permanent Committee, and the Board hopes that you will accept service.

"The Board of Direction has designated Mr. George W. Kittredge to act as Chairman and Mr. J. B. Austin, Jr., to act as Vice-Chairman of the Committee.

"Regarding outline of work, the Board suggests that your Committee select from the list of subjects embodied in your report such items as in the judgment of the Committee are of immediate importance.

"Kindly advise me of your willingness to serve on the Committee on Electricity at your convenience."

The members of the Standing Committee XVIII, on Electricity, named by this letter, were as follows:

George W. Kittredge, Chairman;
J. B. Austin, Jr., Vice-Chairman;
F. A. Bagg,
R. D. Coombs,
E. P. Dawley,
W. W. Drinker,
G. A. Harwood,
C. E. Lindsay,
H. R. Talcott.

Shortly after the appointment of this Committee, Mr. Talcott at his own request was relieved from membership therein and Mr. A. S. Baldwin, Chief Engineer of the Illinois Central Railroad, was substituted. Subsequently Mr. L. C. Fritch was also added to the Committee.

No report was presented at the convention of 1909, owing to the fact that the Committee had just been appointed and had not yet organized.

During the year 1909 meetings were held on July 6 and October 7. Sub-Committees were appointed and the subjects for study and discussion were assigned. The work done by the Committee in the year 1909 is outlined in the Proceedings of the convention of 1910.

Your Committee was instructed by the Board of Direction to consider during 1910 and submit recommendations on the following subjects:

(1) Clearances.
(2) Transmission lines and crossings.
(3) Insulation.
(4) Maintenance organization.
(5) Electrolysis.
(6) Relation to track structures.

Meetings of the General Committee during the year were held as follows:

April 14, New York, at which were present J. B. Austin, Jr., R. D. Coombs, W. W. Drinker, G. A. Harwood.

April 28, New York, at which were present J. B. Austin, Jr., E. P. Dawley, R. D. Coombs, G. A. Harwood, W. S. Murray.

June 9, New York, at which were present George W. Kittredge, Chairman; J. B. Austin, Jr., A. O. Cunningham, R. D. Coombs, G. A. Harwood, C. E. Lindsay.

October 17, New York, at which were present George W. Kittredge, J. B. Austin, Jr., G. A. Harwood, E. B. Katte, C. E. Lindsay.

At the first meeting, held on April 14, the following Sub-Committees were appointed:

Sub-Committee No. 1—Clearances:

G. A. Harwood, Chairman;
R. D. Coombs,
A. O. Cunningham,
W. S. Murray.

At the meeting of June 9, Mr. George Gibbs was added to this Sub-Committee.

At the meeting of October 17, Mr. E. B. Katte was also added to this Sub-Committee.

Sub-Committee No. 2—Transmission Lines and Crossings:

R. D. Coombs, Chairman;
A. O. Cunningham,
G. A. Harwood,
W. S. Murray.

Sub-Committee No. 3—Insulation:

J. A. Peabody, Chairman;
R. D. Coombs,
W. S. Murray.

At the meeting held October 17, Mr. Peabody at his request was relieved of the Chairmanship of this Sub-Committee and W. S. Murray was appointed Chairman in his stead, and E. B. Katte was added to the Sub-Committee.

Sub-Committee No. 4—Maintenance Organization:

J. B. Austin, Jr., Chairman;
E. P. Dawley,
C. E. Lindsay,
E. H. McHenry.

Sub-Committee No. 5—Electrolysis:

W. W. Drinker, Chairman;
W. S. Kinnear,
J. A. Peabody.

Sub-Committee No. 6—Relation to Track Structures:

C. E. Lindsay, Chairman;
E. P. Dawley,
E. H. McHenry,
J. B. Austin, Jr.

At the meeting held October 17, announcement was made of the death of Mr. E. P. Dawley. The Committee passed resolutions of regret at the loss of a valued and efficient member.

The Committee in an attempt to analyze the publications on this subject found that the matter was so profuse and so diversified that it was practically impossible to give a resume of it without the unintentional slighting of important works and feels that it is better to present a partial list of the publications dealing with the subject, which may be found below.

BIBLIOGRAPHY.

GENERAL.

"Steam Locomotive and Electric Operation for Trunk-Line Traffic: a Comparison of Costs and Earnings;" by Joseph Mayer. Transactions American Society of Civil Engineers, v. 57, p. 455 (Paper 1037. Dec., 1906). (Contains discussion by Frank J. Sprague.)

"Electric Railways," by George Gibbs and others. Trans. Am. Soc. C. E., v. 59, p. 330 (Paper 1057. July, 1907.) (A discussion on the factors which determine the maximum economical grade for electric railways.)

"The Substitution of Electricity for Steam as a Motive Power for Suburban Traffic;" by John Findley Wallace. Trans. Am. Soc. C. E., v. 37, p. 133 (Paper 803. June, 1897). (A concise statement of the history and results of certain investigations on the progress of the use of electric motors for transportation purposes.)

"Electricity versus Steam for Branch Railroad Lines;" by H. S. Haines and others. Trans. Am. Soc. C. E., v. 42, p. 375 (Paper 862. Dec., 1899.) (A discussion of the economic conditions under which electricity may be profitably substituted for steam in the operation of branch railroad lines.)

"Practical Aspects of Steam Railroad Electrification;" by W. H. Smith. Transactions American Institute of Electric Engineers, v. 26, Pt. 2, p. 1693 (1907). (Comparison of steam and electricity for steam railroads, economic value.)

"The Approaching Transfer of the Electrification Problem;" by William McClellan, William S. Murray and others. Official Proceedings of the New York Railroad Club, v. 19, p. 1407 (April, 1909). (Discusses the electrification of steam railroads.)

"Developments in Electrification of Railway Terminals;" by H. H. Evans. Journal of the Western Society of Engineers, v. 14, p. 155 (April, 1909). (On the practicability of railway electrification.)

"Bahntechnische Forderungen an den elektrischen Vollbahnbetrieb;" by Arthur Hruschka. Zeitschrift des Osterreichischen Ingenieur und Architekten-Verein, v. 60, pp. 797, 817 (Dec. 4, 11, 1908). (Discusses the problems of applying electric traction to trunk line operations.)

"Electrification of Railroads;" by Frederick Darlington. Journal of the Engineers' Society of Pennsylvania, v. 1, p. 449 (Oct., 1909). (Comparison of steam and electrified railroads.)

"Electric Traction for Trunk Lines." Railroad Gazette, v. 40, pp. 414, 425 (April 20, 27, 1906). (Abstract of report made by K. Kando to Ganz & Co.)

"Alternating Current Electric Systems for Heavy Railway Service;" by B. G. Lamme. Proc. N. Y. R. R. Club, v. 16, p. 157 (March 16, 1906). (Discusses the advisability of changing from steam to electricity of main lines.)

"Some Facts and Problems Bearing on Electric Trunk-Line Operation;" by Frank J. Sprague. Trans. Am. Inst. Elec. Engrs., v. 26, Pt. 1, p. 681 (1907). (Discusses briefly the substitution of electricity for steam and gives at length details of electrical systems.)

"The Electrification of Trunk Lines;" by L. R. Pomeroy. Journal American Society of Mechanical Engineers, v. 32, p. 145 (Feb., 1910).

"Development and Design of the Electric Locomotive;" by Theodore Rich. Cassiers' Magazine, p. 421, v. 37 (March, 1910). (The electrical equipment of locomotives dealt with briefly and merits of the different electrical systems discussed.)

"La Locomotive Electrique Systeme." J. J. Heilman, Rue de Grammont 30, Paris. (Illustrated description of an electric locomotive.) (Ad-249.)

"Design of the Electric Locomotive;" by N. W. Storer and G. M. Eaton. Proc. Am. Inst. Engrs., v. 29, No. 7 (July, 1910). (Discussion of a few principles of the design of the locomotive.)

."Traite Pratique de Traction Electrique;" v. 2, p. 1035, by L. Barbillion and G. J. Griffisch. E. Bernard, Paris, 1904. (One chapter considering the application of electric traction for railroads.)

"Electrical Locomotives and Multiple-Driven Axles;" by Edward H. Tyler. Engineering, v. 70, p. 805 (Dec. 21, 1900.) (On the circumstances that must determine which is the better system.)

"Why Steam Locomotives Must Be Replaced by Electric Locomotives for the Heaviest Freight Service;" by H. Ward Leonard. Elec. World, v. 45, p. 27 (Jan. 7, 1905). (Presents facts and arguments tending to show that the electric locomotives will, because of their great economic superiority, replace steam locomotives for the heaviest freight traffic.)

"Electric Railway Engineering;" by H. F. Parshall and H. M. Hobart. D. Van Nostrand Co. New York, 1907. (The book deals with the mechanics of electric traction, the generation and transmission of the electrical energy and the rolling stock.)

"Heavy Electrical Engineering;" by H. M. Hobart, p. 240. D. Van Nostrand Co., New York. 1908. (Contains a long chapter on traction motors and the electrification of railways.)

"Electric Railways, Theoretically and Practically Treated;" by Sydney W. Ashe and J. D. Keiley, p. 252. D. Van Nostrand Co. New York. 1905. (A chapter on electric locomotives.)

"Enormous Possibilities of Rapid Electric Travel;" by Charles Henry Davis and F. Stuart Williamson. Engineering Magazine, v. 14, pp. 33, 253 (Oct.-Nov., 1897). (The purpose of this paper is to show the engineering problems involved in producing by the use of electric motors a speed supposed to be thought of only by visionary people.)

"High-Speed Electric Railway Work;" by F. W. Carter. Mechanical Engineer, v. 14, p. 920 (Dec. 24, 1904). (Considers in a general way the problem of operating high-speed passenger trains making few stops.)

"Electric Railway Developments;" by Horace T. G. Eddy. Scientific American, v. 93, p. 23 (July 8, 1905). (A brief general review.)

"Catenary Trolley-Line Construction;" by Geo. W. Cravens. Electrical Review and Western Electrician, v. 55, p. 626 (Oct. 2, 1909). (Discusses the advantage of the catenary systems.)

"The 1,200-Volt Railroad—A Study of Its Value for Interurban Railways;" by Charles E. Eveleth. Proc. Amer. Inst. of Elec. Engrs., v. 29, p. 589 (April, 1910). (A paper dealing with the economic side and giving many tables of cost data.)

"Report of Committee on Electrification." Official Proceedings of the New York R. R. Club, v. 20, p. 1972 (April, 1910). (The Committee have made a review of the whole subject and limited the report to a discussion of the electrification of steam railroads as applied to terminals and trunk-line operation.)

"Electrical Traction on Railways;" by William Morris Mordey and Bernard Maxwell Jenkins, M. Inst. C. E. Proceedings Institution of Civil Engineers, v. 149, p. 40 (Paper 3331, Feb. 18, 1902). (A general review of the principal systems of electrical traction in use, and an examination of the advantage and disadvantage of each.)

"Electricity as a Substitute for Steam in Heavy Railroad Service;" by Arthur M. Waitt. Railway Age, v. 37, p. 334 (March 4, 1904). (Considers the practicability of the introduction of electricity on steam railroads.)

"Some Notes on Acceleration, Electric vs. Steam;" by P. Walter d'Alton and John Mannheim. The Engineer, v. 96, p. 443 (Nov. 6, 1903). (Two pages.)

"Application of Electricity to Steam Roads;" by L. S. Randolph. Railway and Engineering Review, v. 44, p. 559 (July 30, 1904). (Paper before the Richmond Railway Club. Discusses the advantages and disadvantages of the electrical system.)

"The Methods Employed for Working Electric Railways;" by E. C. Zehme. Bul. Inter. Ry. Cong., v. 23, p. 1795 (Dec., 1909). (A description of the means employed on the different systems of working electric railways.)

"Electrification of Trunk Lines;" by L. B. Pomeroy. R. R. Gazette, v. 38, p. 531 (May 19, 1905). (A study of the comparative cost of operating and the cost of installation of electric railways.)

"Electrical Working of Main Line Railways;" by Ernest Kilburn Scott. Electrical Review, v. 47, p. 897 (Dec. 7, 1900.) (A discussion of paper by W. Langdon on the supersession of the steam by the electric locomotive, read before the Inst. of Elec. Engrs., England.)

"Single-Phase Railways;" by Percy C. Jones. Journal of the Institution of Electrical Engineers, v. 43, p. 723 (Dec., 1909). (The paper describes some recent railway equipments on the single-phase system.)

"Electrification of Our Railways;" by Philip Dawson. Elec. Rev., v. 49, p. 959 (Dec. 13, 1901). (Discusses especially the problem as related to suburban traffic.)

"Electrification of Railways;" by George Westinghouse. Jour. Amer. Soc. of Mech. Engrs., v. 32, p. 1133 (July, 1910). (The paper directs the attention to the selection of a comprehensive electrical system embracing fundamental standards of construction.)

"Some Notes on Railroad Electrification Matters;" by C. L. de Muralt. The Michigan Technic, v. 22, p. 4 (Feb., 1909). (An explanation of the difference in continuous current, single-phase and three-phase systems.)

"Financial Aspect of the Application of Electric Motive Power to Railroads;" by F. Darlington. Eng. Mag., v. 38, p. 663 (Feb., 1910). (Discusses the relative economy in both local and long-distance traction.)

"Economics of Railway Electrification;" by Wm. Bancroft Potter. Jour. Am. Soc. Mech. Engrs., v. 32, p. 1183 (July, 1910). (This article treats of the economic side of the subject, giving cost data and comparative tables of expenses between steam and electricity.)

"Heavy Electric Railroading;" by Bela Valatin. Elec. World, v. 46, p. 860 (Nov. 18, 1905). (A comparison of the three different systems which are to be used for moving heavy train units where electricity is to replace the steam locomotives.)

"Electrification of Railways;" by H. W. Wilson. Liverpool Engineering Society, v. 26, p. 181 (1904-5). (Considers the adaptability of different methods of electrical operation of railways to varying conditions.)

Abstract of same, Mech. Engr., v. 15, p. 486 (Sept. 30, 1905).

"Ueber elektrische Zugforderung auf normalen Eisenbahnen;" by Br. Bohn-Raffay. Zeitschrift des Oesterr. Ingenieur-und Architekten-Vereines, v. 54, p. 882 (Dec. 19, 1902). (A discussion of the practicability of applying electric locomotives to main line service.)

"The Railway Electrification Problem and Its Probable Cost for England and Wales;" by F. F. Bennett. Jour. Inst. of Elec. Engrs., v. 33, p. 507 (1904).

Abstract of same, "The Railway Electrification Problem;" by F. F. Bennett. Mech. Engr., v. 13, pp. 361, 423 (March 12, 19, 1904).

"Electric Traction on Steam Railways;" by Alton D. Adams. Cassiers' Mag., v. 23, p. 736 (April, 1903). (Discusses the systems tried, their cost, advantages and disadvantages.)

"Electrical Problems of Main-Line Railway Traction;" by Charles T. Child. Eng. Mag., v. 23, p. 701 (Aug., 1902). (A comprehensive general statement of conditions to be met in heavy railway service, showing the limitations of modern electric motors for railway use.)

"Developments in Heavy Electric Traction;" by C. L. DeMuralt. R. R. Gazette, v. 36, p. 285 (April 15, 1904). (Discusses the alternating current systems in use and the problems connected with the electrification of existing steam roads.)

"Heavy Traction Problems in Electrical Engineering;" by Carl L. De Muralt. Trans. Am. Inst. Elec. Engrs., v. 24, p. 525 (1905). (Considers only problems relating to traction on through lines.)

"Electric Traction on Main Lines." Eng., v. 73, p. 481 (April 11, 1902). (Editorial review of paper by E. Huber before the Zurich Assn. of Engrs. and Archts.)

"The Position and Protection of the Third-Rail on Electric Railways;" by William E. Langdon. The Electrician, v. 51, p. 447 (July 3, 1903). (One page.)

"High-Speed Electric Traction on Railways;" by J. W. Jacomb-Hood. Electrician, v. 51, p. 446 (July 3, 1903). (Two columns.)

"Electric Traction for Railroad Service;" by J. A. Shaw. Engineering Record, v. 52, p. 423 (Oct. 14, 1905). (The advantage of electricity over steam, the systems available and the merits of each.)

"Developments in Electric Traction;" by W. B. Potter. Proc. N. Y. R. R. Club, v. 15, pp. 111, 195 (Feb.-April, 1905). (Comparison of steam and electrically operated railroads.)

"Electric Traction on Railways." Eng., v. 79, p. 660 (May 26, 1905). (Discusses the main points that are essential for success of electric traction on railways.)

"Consideration sur l'Avenir de la Traction Electrique sur les Grandes Lignes de Chemins de Fer." La Revue Technique, v. 25, pp. 15, 80 (Jan. 10, 25, 1904). (A comparison of the results attained upon local and municipal railways with the requirements for main line service.)

"Electric Traction for Heavy Railway Service;" by Edward P. Burch. Engrs.' Year Bk., Univ. of Minnesota, v. 9, p. 81 (1901). (The purpose of the paper is to show the present status of electric railway engineering and to give reasons why the electric motive power will supplant the steam locomotive for heavy railway service.)

"Les Chemins de Fer Electriques;" by M. Leon Gerard. Memoires de la Societe des Ingenieurs Civils de France, 1902, v. 1, p. 442. (A general review of electric traction of all kinds and comparisons between it and steam traction with classification tables of electric railways.)

"Electric Traction on Urban and Interurban Steam Railways;" by H. E. O'Brien. Liverpool Eng. Soc., v. 29, p. 333 (1908). (On electrification of existing steam railways; with tables.)

Abstract of same, Electrician, v. 62, p. 576 (Jan. 22, 1909).

"The Introduction of Electric Traction on Main Line Railways;" by E. Frischmuth. Bul. Inter. Ry. Congress, v. 23, p. 828 (Aug., 1909). (Discusses the advantages, working, maintenance system, etc., of electric railways.)

"Electrification of Railways—A General Comparison of Systems;" by F. W. Carter. The Rugby Engineering Soc., v. 6, p. 37 (Feb. 18, 1909). (Compares in a general way the merits and demerits of the various systems of operation, showing that no one system satisfies all needs, and indicates the class of work to which each is suited.)

Abstract of same, Mechanical Engineer, v. 23, p. 270 (Feb. 26, 1909).

"Cost of Electrically-Propelled Suburban Trains;" by H. M. Hobart. Eng., v. 90, p. 249 (Aug. 12, 1910). (A comparison of systems showing that the continuous system has decided commercial advantages over the single-phase system for this service; paper read before the Institution of Mechanical Engineers.)

"Long-Distance Electric Railroading;" by Louis Duncan. Technology Quarterly (Dec., 1902). (Discusses the application of electricity to traction on tramways, suburban and interurban roads, and the field at present occupied by steam locomotives, reviewing the systems, and showing the methods now used are not applicable on steam roads, but thinks the problem will yet be solved.)

"United States: Bureau of the Census, Special Reports, Street and and Electric Railways, 1907." Pp. 221, 253, 300. Washington. Government Printing Office. 1910. (Contains data on the use of electricity by steam railroads.)

"Inleiding tot de Studie van het Hyro-electrische Vraagstuk Betreffende de Spoorwegen op Java;" by J. K. Lagerway. Ingenieur, v. 24, p. 762 (Oct. 2, 1909). (A study of the possibility of supplying electric power for the railways of Java.)

"Electricity vs. Steam for Heavy Haulage;" by A. H. Armstrong. St. Ry. Jour., v. 25, p. 820 (May 6, 1905). (An inquiry into the limitations of steam locomotives and comparing with the tests made upon the electric locomotives designed for the N. Y. C. R. R.)

"Transactions of the International Electrical Congress, St. Louis, 1904." V. 3, p. 272. "The Electrification of Steam Railroads;" by Bion J. Arnold. (How to make the most effective use of the high-pressure transmission and high-tension working conductor and maintain safety of operation.)

Abstract of same, "Application of Electricity to Steam Railroads;" by Bion J. Arnold. R. R. Gaz., v. 37, p. 414 (Oct. 17, 1904).

"Some Phases of Steam-Railroad Electrification in the United States;" by Edward N. Lake. Eng. Mag., v. 37, p. 483 (July, 1909). (A study of progress and discussion of the outlook.)

"Choice of Motors in Steam and Electric Practice;" by William McClellan. Trans. Am. Inst. Elec. Engrs., v. 24, p. 561 (June, 1905). (Discusses railway motive power and speaks of lack of systematic classification of locomotives and electric motors; four tables of locomotive data.)

"Electric Traction on Long Distance Railways;" by Alton D. Adams. Scientific American, v. 87, p. 414 (Dec. 13, 1902). (Reviews what has been done in Europe and America to solve this problem; very brief.)

CANADA.

GRAND TRUNK PACIFIC RAILWAY.

"Proposed Electrification of Part of the Grand Trunk Pacific." Railroad Age Gazette, v. 46, p. 927 (April 30, 1909). (Editorial on the proposal to electrify the portion of the line between the St. Lawrence River and Moncton, New Brunswick.)

UNITED STATES OF AMERICA.

GENERAL.

"Report on the Question of Electric Traction;" by George Gibbs. Bulletin of the International Railway Congress, v. 24, p. 239 (Jan., 1910). (On the conversion of existing steam railroads to electric traction.)

"The Substitution of Electricity for Steam as a Motive Power;" by J. G. White. Trans. Am. Soc. C. E., v. 54, Pt. E, p. 3 (Paper 60. Inter. Eng. Congress. 1904). (A review of the work accomplished in America during the previous decade. As far as possible the figures used are the results of actual experience or of tests.)

"Bau elektrischer Hauptbahnen in den Vereinigten Staaten;" by E. C. Zehme, Glaser's Annalen fur Gewerbe und Bauwesen, v. 64, pp. 248, 265 (June 1, 8, 1909). (Electric Trunk Line Construction in the United States. A discussion of the various important lines.)

"The Substitution of Electric Power for Steam on American Railroads;" by F. Darlington. Engineering Magazine, v. 37, p. 900 (Sept., 1909). (A discussion with reference to American Practice, concluding that self-preservation demands its progressive adoption.)

ANNAPOLIS SHORT LINE.

"From Steam to Electricity on a Single-Track Road;" by J. B. Whitehead. Transactions American Institute of Electrical Engineers, v. 27, Pt. 2, p. 1139 (1908). (Gives comparative cost of steam and electrical operation on the Annapolis Short Line.)

CHICAGO TERMINAL.

"Electrification of Chicago Railways;" by C. A. Seley. Official Proceedings Western Railway Club, v. 22, p. 113 (Nov. 16, 1909). Seventeen pages.)

"Electrification of Railroad Terminals in Chicago." (Editorial.) Electrical Review and Western Electrician, v. 55, p. 619 (Oct. 2, 1909).

"Railroad Terminal Electrification Made Mandatory in Chicago." (Editorial.) Electrical Review and Western Electrician, v. 55, p. 624 (Oct. 2, 1909). (This editorial gives an ordinance of the city council of Chicago for all railroads operating in the city within eight miles of City Hall to propel all cars and trains by electric power.)

"A Proposal to Force the Railways Entering Chicago to Adopt Electricity." (Editorial.) Engineering News, v. 62, p. 386 (Oct. 7, 1909). (On the unreasonableness of the demand.)

DENVER & INTERURBAN RAILROAD.

"Catenary Trolley Construction;" by Oliver S. Lyford, Jr. Trans. Am. Soc. C. E., v. 62, p. 157 (Paper 1096. March, 1909). (This paper presents the results of the latest practical experience with catenary trolley construction on Denver & Interurban Railroad.)

GREAT NORTHERN RAILWAY.

"The Electric System of the Great Northern Railway Company at Cascade Tunnel;" by Cary T. Hutchinson. Transactions of the American Institute of Electrical Engineers, v. 28, p. 128 (1909). (Describes the first three-phase installation on a trunk line railway in the United States.)

LONG ISLAND RAILROAD.

"Work Done, Number Three;" publication of the Westinghouse, Chuch, Kerr & Co. engineers. (A description of the electrification of the Long Island R. R., with illustrations of the work accomplished.) (Ad-310.)

"The Pennsylvania Railroad's Extension to New York and Long Island—The Long Island City Power Station." St. Ry. Jour., v. 27, p. 536 (April 7, 1906). (An illustrated description of the building of the power station.)

"The Power Transmission Line and Third-Rail System of the Long Island Railroad;" by W. N. Smith. St. Ry. Jour., v. 27, p. 896 (June 9, 1906). (A detailed description, with some general remarks on the arrangement of the power transmission and distribution system.)

"The Rotary-Converter Sub-Stations of the Long Island Railroad;" by W. N. Smith. St. Ry. Jour., v. 27, p. 968 (June 23, 1906). (A description of the general scheme of power distribution to the several lines.)

"Problems of Heavy Electric Traction;" by O. S. Lyford, Jr., and W. N. Smith. Trans. Am. Inst. Elec. Engrs., v. 23, p. 691 (1904). (A study of the general subject of electric traction for the suburban lines of present steam roads; Long Island Railroad used as a typical example.)

ST. CLAIR TUNNEL.

"Electrification of the St. Clair Tunnel;" by F. A. Sager and Bion J. Arnold. The General Passenger Dept., Grand Trunk Ry. System, Montreal. 1908. (An illustrated technical description.)

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

"The Electrification of the Suburban Zone of the New York Central & Hudson River Railroad in the Vicinity of New York City;" by William J. Wilgus, Trans. Am. Soc. C. E., v. 61, p. 73 (Paper 1079. Dec., 1908). (Discusses reasons for electrification of New York Central; gives comparative tests of steam and electric locomotives, etc.)

"Care and Handling of Electrical Equipment, New York Central & Hudson River;" by F. E. Lister. Railway Age Gazette, v. 48, p. 1367 (June 3, 1910). (Organization of the Electrical Department, a number of methods illustrated which could be applied, in part at least, to advantage in handling steam railway equipment.)

"Notes Taken During a Journey of Inquiry in the United States;" by Em. Uytborck. Bulletin of the International Railway Congress, v. 22, p. 1173 (Nov. 1908). (Principally an illustrated description of the electrification of the N. Y. C. & H. R. R. and the N. Y., N. H. & H. lines and their equipment, with criticism and comparison.)

NEW YORK, NEW HAVEN & HARTFORD RAILROAD.

"The Log of the New Haven Electrification;" by W. S. Murray. Trans. Am. Inst. of Elec. Engrs., v. 17, Pt. 2, p. 1613 (1908). (Describes the actual operation of the New Haven single-phase electrification.)

EUROPE.

"Electric Traction of Main Line Railways in Europe;" by Philip Dawson. Street Railway Journal, v. 27, p. 520 (April 7, 1906). (Gives causes tending to the electrification of main-line railways.)

"Electric Traction on the Continent;" by A. J. Thompson. Cassiers' Mag., v. 37, p. 692 (April, 1910). (Installations of electric traction in Switzerland and Germany.)

AUSTRIA-HUNGARY.

"Chemins de Fer;" "Les Chemins de Fer Electriques en Autriche-Hongrie." Le Genie Civil, v. 57, p. 124 (June 18, 1910). (A description of several lines of railroad on which electricity has been used.)

"On the Question of Electric Traction;" by Arthur Hruschka. Bul. Inter. Ry. Congress, v. 24, p. 2712 (June, 1910). (In three parts—electric full-gage railways in actual operation, under construction, and planned and under consideration in Austria and Hungary.)

BELGIUM.

"Light Railways of Belgium;" by Lionel Wiener, Cassiers' Mag., v. 37, p. 732 (April, 1910). (Describes an intermediate system between railways and tramways which has recently been electrified.)

GERMANY.

"Electrification of the Bavarian State Railways;" by J. Jacquin. Bul. of the Inter. Ry. Congress, v. 24, p. 467 (Jan., 1910). (A review of the report given by the Bavarian Minister of Transportation.)

"The Substitution of Electricity for Steam as a Motive Power;" by Alexander Siemens, M. Inst. C. E. Trans. Am. Soc. C. E., v. 54, Pt. E, p. 51 (Paper 61. 1904). (A statement of conclusions reached thus far from the experimental work on the line between Marienfeld and Zossen.)

Abstract of same, Railroad Gazette, v. 37, p. 445 (Oct. 14, 1904).

"On the Question of Electric Traction;" by Gleichman. Bul. Inter. Ry. Congress, v. 24, p. 1071 (March, 1910). (Preliminary work for the introduction of electric operation on the German main railways.)

GREAT BRITAIN.

"Electrification of Railways:" by John A. F. Aspinall. Proceedings, Institution of Mechanical Engineers, 1909, p. 423 (April). (Discusses the electrification of the Lancashire & Yorkshire Ry.)

Abstract of same, Engineering, v. 87, p. 609 (April 30, 1909).

"Electrification of the Heysham, Morecambe and Lancaster Branch of the Midland Railway;" by Em. Uytborck. Bulletin of the International Railway Congress, v. 23, p. 278 (April, 1909). (Describes the various installations, calling attention to the special peculiarities.)

"The Electrification of the South London Line of the London, Brighton & South Coast Railway." Railroad Age Gazette, v. 47, p. 247 (Aug. 6, 1909). (Brief illustrated account of work in progress in England and the equipment adopted.)

"Railway Electrification;" by Philip Dawson. The Electrical Review, v. 64, pp. 204, 275 (Feb. 5, 12, 1909). (Briefly considers a few advantages in the case of long-distance lines, especially discussing the advantages to British railways by the electrification of suburban lines.)

"Electrification of Steam Railways in England;" by Philip Dawson. Railway Age, v. 38, p. 233 (Aug. 19, 1904). (Discusses the impracticability of third-rail electric traction on British railways.)

"British Railways, Some Facts and a Few Problems;" by W. E. Dalby. Engineering, v. 90, p. 347 (Sept. 2, 1910). (Part of this article treats of electric railways in Great Britain.)

"The Electrification of British Railways." Street Ry. Jour., v. 22, p. 8 (July 4, 1903). (Reviews briefly what has been accomplished on the continent of Europe and discusses the peculiar features of the problem in Great Britain. Contains maps.)

"Equipment and Working Results of the Mersey Railway Under Steam and Under Electric Traction:" by Joshua Shaw. Minutes of Proceedings of the Institution of Civil Engineers, v. 179, p. 19 (1909-10), Pt. 1).

"Single-phase Electrification of the Heysham, Morecambe and Lancaster Branch of the Midland Railway;" by James Dalziel and Josiah Sayers. Minutes of Proceedings of the Institution of Civil Engineers, v. 179, p. 47 (1909-10, Pt. 1.)

"Effect of Electrical Operation on the Permanent-Way Maintenance of Railways, as Illustrated on the Tynemouth Branches of the North Eastern Railway:" by Charles A. Harrison. Minutes of Proceedings of the Institution of Civil Engineers, v. 179, p. 99 (1909-10, Pt. 1). (Followed by a long discussion on Electric Traction on Railways.)

Transactions of the International Electrical Congress, St. Louis, 1904, v. 3, p. 7, "Electric Traction on British Railways;" by Philip Dawson. (A brief discussion giving advantages.)

"Electricity as a Motive Power on Railways;" by C. A. Carus-Wilson. Engineering, v. 72, p. 334 (Sept. 6, 1901). (Deals with the economic considerations governing the substitution of electricity for steam as a motive power on railways; refers principally to British railways.)

"Electrification of Suburban Railways;" by F. W. Carter. Eng., v. 90, p. 281 (Aug. 19, 1910). (Discusses the advantages of electrification of existing steam-operated lines for suburban service in England; paper read before the Institution of Mechanical Engineers.)

"Electric Traction in Its Relation to Existing Railways;" by J. W. Jacomb-Hood. Electrician, v. 49, p. 1037 (Oct. 17, 1902). (Discusses mainly as to the application of electricity to suburban service and the cost in Great Britain.)

ITALY.

"Electrification of Italian State Railway, Three-phase Freight Locomotives of the Giovo Line;" by Warren H. Miller. Electrical World, v. 56, p. 326 (Aug. 11, 1910). (An illustrated account of the equipment of this railroad.)

"Electrification of the State Railways of Italy." The Engineer, v. 107, p. 385 (April 16, 1909). (Extracts from information supplied by the general director of the State Railways of Italy.)

"Versuchsergebnisse uber Stromverbrauch und Ruckgewinnauf der Valtellinabahn und einige Eigenheiten der Drehstromtoraktion;" by Eugen Cserhati. Zeit. des Oesterr. Ing. und Arch. Ver., v. 57, p. 345 (June 9, 1905). (Examination of the efficiency of polyphase traction on the Valtellina Railway.)

"Der elektrische Betrieb von Vollbahnen mit Hochspannung und dessen Wirtschaftlichkeit;" by Friedrich Ross. Zeit. des Oesterr. Ing. und Arch. Ver., v. 53, p. 377 (May 24, 1901). (Operation of Valtellina Railway between Lecco and Chiavenna by electric locomotives.)

"Operating Results of the Valtellina Railway—Peculiarities of the Three-phase Traction;" by Eugen Cserhati. Street Railway Journal, v. 26, p. 303 (Aug. 26, 1905). (Operating costs, current consumption tests. recuperation of energy, etc.)

"The Valtellina Railway." The Engineer, v. 99, p. 438 (May 5, 1905). (Working costs, tests made and general working.)

"Der Betrieb der Valtellina-Bahn mit hochgespanntem Drehstrom;" by Eugen Cserhati and Koloman von Kando. Zeit. des Ver. deutsch. Ing., v. 47, pp. 185, 276, 303 (Feb. 7, 21, 28, 1903). (A complete account of the Valtellina electric railway in which the Ganz polyphase system is used.)

"Le Chemin de Fer Electrique de la Valteline." Revue Technique, v. 22, p. 340 (Aug. 10, 1901). (General description of the application of three-phase electric traction to main railway between Lecco and Sondrio, Italy.)

"Chemin de Fer Electrique de la Valteline (Italie) Utilisation Directe des Courants Triphases a Haute Tension;" by Henry Martin. Gen. Civ., v. 21, p. 101 (June 15, 1901). (A full description of the three-phase high-pressure system as applied to sixty-five miles of main railway.)

"The Valtellina Railway." Electrician, v. 51, pp. 19, 68 (April 24, May 1, 1903). (An illustrated description.)

"The Valtellina Electric Railway." Electrical Review, v. 53, pp. 543, 583 (Oct. 2, 9, 1903). (Nine pages.)

"The Three-phase Railway at Valtellina." St. Ry. Jour., v. 21, p. 788 (May 30, 1903). (Ten pages.)

"The Valtellina Electric Railway;" by Emile Guarini. Railway Age, v. 35, p. 926 (May 29, 1903). (Two pages.)

"Erfahrungen und Ergebnisse des zweijahrigen electrischen Betriebes mit hoch gespanntem Drehstrom auf der Valtellina-Bahn;" by Eugen Cserhati. Zeit. des Ver. deutsch Ing., v. 40, p. 125 (Jan. 28, 1905). (Results of two years' operation of the Valtellina Railway from a technical and commercial standpoint.)

"Some Features of the Valtellina Three-phase Railway;" by Cesare Pio. Electrical World, v. 40, p. 689 (Nov. 1, 1902). (Illustrated description, one and a half pages.)

"Valtellina High-Tension Three-phase Railway." The Engr., v. 95, pp. 110, 138, 234 (Jan. 30, Feb. 6, March 6, and Sup. Feb. 20, 1903.)

"The Ganz Three-phase Electric Railway System;" by G. Leve. Railroad Gazette, v. 37, p. 388 (Sept. 30, 1904). (Contains information concerning the Valtellina line.)

"The Valtellina Line and the Electrical Operation of Railroad Main Lines;" by Theodore Kohn. Railroad Gazette, v. 38, pp. 185, 353, 375, 400, 648 (March 3, April 14, 21, 28, June 9, 1905.)

"Electric Traction." P. 349. By Robert H. Smith, New York. Harper Bros., New York City. 1905. (The book has both maps and illustrations and contains information on electric railway in Valtellina, Italy.)

"Locarno-Pontebrolla-Bignasco Railway;" by H. Marchand-Thiriar. Bul. Inter. Ry. Cong., v. 23, p. 18 (Jan., 1909). (Electric traction by simple alternating current in Europe.)

"The New Three-phase Ganz Locomotives of the Valtellina Railway;" by H. Marchand-Thiriar. Bul. Inter. Ry. Cong., v. 23, p. 96 (1909). (A description of the locomotives and motors employed on the Valtellina Railway.)

NORWAY.

"Norwegian Single-phase Railway." Railway Age Gazette, v. 49, p. 389 (Sept. 2, 1910). (An illustrated account of the equipment of this railroad.)

SWEDEN.

"Electrification of the Lapland Railway." Eng., v. 90, p. 23 (July 1, 1910). (This article gives details of the definite plans, with a map of the district affected by electric installation on the Lapland Railway.)

"The Electrification of the Swedish State Railways." Eng., v. 84, p. 819 (Dec. 13, 1907). (An abstract of a report on these railways prepared by Mr. Robert Dahlander.)

"Experimental Electric Traction on the Swedish State Railways, 1905-1907." Eng., v. 86, p. 248 (Aug. 21, 1908). (A short abstract of a report on the electrification of the Swedish State Railways and the satisfactory results of which have led to the present extensive plans.)

Abstract of same, Bul. Inter. Ry. Cong., v. 23, p. 147 (Feb., 1909).

SWITZERLAND.

"Electric Traction by Simple Alternating Current on European Railways;" by H. Marchand-Thiriar. Bul. Inter. Ry. Cong., v. 23, p. 206 (March, 1909). (A brief description of the Seebach-Wettingen Line.)

AUSTRALIA.

"Report Upon the Application of Electric Traction to the Melbourne Suburban Railway System;" by Charles H. Merz. Victorian Railway Commissioners, Mr. Tait, Chairman, Melbourne, Victoria. (Comparison with steam service.)

Abstract of same, "Electrification of the Melbourne Suburban Railways." Electric Railway Journal, v. 32, p. 751 (Oct. 3, 1908).

"Victorian Railways—Further Report in Respect to the Application of Electric Traction to the Melbourne Suburban Railway System;" by Charles H. Merz, and Report and Comments Thereon by the Victorian Railway Commissioners, Melbourne, March 8, 1909.

"Victorian Railways—Report Including Review and Comments of the Victorian Railway Commissioners in Connection with the Report on the Application of Electric Traction;" by C. H. Merz, Melbourne, Nov. 16, 1908.

"Electric Operation of Steam Railways;" by J. B. Whitehead. Popular Science Monthly (March, 1909). (Examines the advantages and disadvantages of the electric operation of trunk lines.)

"Railway Electrification;" by N. W. Storer. Sibley Journal of Eng. (June, 1909). (Abstract of a lecture on reasons why railways should be electrified.)

"Electric Power for Railroad Operation;" by Fred Darlington. Proceedings Richmond Railroad Club (March 14, 1910). (Mainly a discussion of the commercial aspects.)

"Electrical Operation of Trunk Lines from a Military Point of View" (Die Aussichten des elektrischen Vollbahnbetriebes mit besonderer Berucksichtigung der militarischen Bedenken.) By R. Rinkel. (Elek. Kraft und Bahnen, May 24, 1909.) (With special reference to conditions in Germany.)

"Introduction of Electric Traction on Trunk Lines" (Ueber die Einfuhrung des elektrischen Zugbetriebes auf Vollbahnen); by E. Frischmuth. Elektrische Kraftbetriebe und Bahnen (Oct. 24, 1908). (A general review of progress in Europe and America.)

"Electric Traction on Railways" (La Trazione Elettrica nelle Ferrovie); by D. Civita. Elletricita (Nov. 17, 24, Dec. 8, 1900). (A general discussion as to the practicability of the introduction of electric traction on main line railways. Three articles.)

"Supersession of the Steam Locomotives;" by W. E. Warrilow. Elec. Engr., London (Aug. 16, 1901). (Discusses the scheme proposed by Mr. Langdon in his paper, "The Supersession of the Steam by the Electric Locomotive," and does not favor the conversion of the steam railway to the electric, and says inventive energy should be directed toward aeronautics.)

"On the Supersession of the Steam by the Electric Locomotive;" by W. Langdon. Electrical Engineer, London (Nov. 30, 1900). (Considers the question to be mainly a matter of economy.)

"Electric Traction in Its Relation to Existing Railways;" by J. W. Jacomb-Hood. Transport (July 11, 1902). (Read before the London & Southwestern Railway Debating Society. A discussion of the subject from the point of view of a practical railway operator. Considers the possible advantages of electricity over steam service, etc.)

"Standard Gage and High-Speed Electric Railways" (Ueber Elektrische Voll und Schnellbahnen); by Max Schiemann. Elektrotechnische Zeitschrift (July 25, 1901). (A discussion of the problem of the application of electric driving to main-line railways, in view of what has already been accomplished in tramways.)

"Steam or Electricity" (Dampf oder Elektrizitat); by Alfred Birk. Oesterreichische Monatschrift fur den offentlichen Baudienst (Oct. 10, 1903). (A comparison of steam and electric power for the future attainment of high speed on main-line railways, showing the possibilities of the latter.)

"Electricity as a Motive Power on Trunk Lines;" by Cornelius Vanderbilt. North Am. Review (Dec., 1902). (Considers, in a general way, the reasons pro and con, drawing conclusions from an examination of the principles involved.)

"High-Speed and Electric Operation on Standard Railways" (Ueber Schnellbahnen und Elektrische Zugforderung auf Hauptbahnen); by Mr. Wittfeld. Glaser's Annalen (March 1, 1902). (A discussion before the Verein fur Eisenbahnkunde of the comparative merits of steam and electric traction.)

"Electric Traction for Heavy Railway Service;" by Edward P. Burch. Street Railway Review (Jan. 15, 1901). (Read before the Northwest Railway Club. Shows the present standing of electric railway engineering and gives reasons why electric motive power will supplant the steam locomotive for heavy service.)

"The Relative Efficiency of Electric and Steam Locomotives" (Die Leistungsfahigkeit der durch den Elektrischen Strom und der durch Dampkraft Betriebenen Lokomotiven); by Mr. Beyer. Glaser's Annalen (July 1, 1902). (A general discussion of electric vs. steam traction on standard railways.)

"Electric Traction on Steam Railroads;" by Edwin B. Katte. Sibley Journal of Engineering (Dec., 1908). (From a lecture delivered at Harvard University. Remarks on the advantages of electric operation, the systems commonly used, and the electrification recently installed on the N. Y. C. & H. R. R.)

"New York Central Railway Electrification." Tramways and Railway World (Jan. 7, 1909). (Brief illustrated description of the conversion of a part of this steam railway to electric traction on the continuous current system.)

"Competition Between Steam and Electric Railways in the United States;" by Daniel Royse. Transport (July 4, 1902). (Comparing the advantages and disadvantages of the two classes of roads when they are competitors.)

"Electricity Versus Steam for Heavy Railway Service;" by L. D. Tandy. Tramway and Railway World (May 9, 1901). (A comparison of lines in operation in the United States showing the advantages over steam and saving in operating expenses.)

"The Application of Electricity to Steam Roads;" by L. S. Cass. Proceedings Iowa Railway Club (Dec., 1904). (Gives results from practice on eighty miles of track over which are operated electric street cars, interurban cars, electric switch engines and standard and mogul steam locomotives.)

"Electric-Traction Studies in Switzerland" (Gli Studii per la Trazione elettrica in Svizzera); by Emilio Gorli. L'Ingegnieria Ferroviaria (June 1, 1909). (A resume of the results of recent extended investigations.)

"Report of the Swiss Commission on Electrification" (Mitteilungen der Schweizerischen Studienkommission fur elektrischen Bahnbetrieb); by W. Wyssling. Schweizerische Bauzeitung (Oct. 17, 1908). (Results of an investigation of the possibilities of electric traction on Swiss railways.)

"Vergleich zwischen Dampf und Elektrischer Traktion auf Vollbahnen;" by E. Czerhati. Glaser's Annalen (Aug. 1, 1903). (A discussion of the applicability of electric traction to main railways based upon the experience with the Valtelina line in Northern Italy.)

"Difficulties of Underground Transmission for Trunk Line Electrification;" by William A. Delmar. Electrical Age (June, 1909). (An examination of construction and operation difficulties in underground transmission. This magazine is at the binder's.)

These references result from an examination of the following:

Engineering Index, 1901 to 1905, inclusive, under Electric Railways, Steam Compared, and Valtelina, Italy.

Engineering Index Annual, 1906-1909, inclusive (German articles partially omitted).

Technical Press Index, Jan., 1908, to June, 1909, inclusive.

Special Reports of the U. S. Census Bureau on Street and Electric Railways for 1907.

Search No. 476.

Technical Index to Current Engineering Literature, Oct., 1909, to Oct., 1910, inclusive.

Catalogue of the Library.

Transactions American Society Civil Engineers, 1867, to Sept., 1910, inclusive.

SUB-COMMITTEE NO. 1, CLEARANCES.

The following report was received from the Sub-Committee at the meeting of October 17:

During the year this Sub-Committee has held meetings as follows:

At New York, June 9, at which Messrs. G. A. Harwood, A. O. Cunningham and W. S. Murray were present.

At Cleveland, Ohio, September 10, at which Messrs. Harwood and Cunningham were present.

At New York, October 6, at which Messrs. Harwood and J. D. Keiley, representing Mr. Katte, were present.

In addition, matters have been discussed with members by correspondence and personal interviews.

DEFINITIONS.

Third-Rail Clearance Line.—Lines beyond which no part of the third-rail structure shall project.

Equipment Clearance Lines.—Lines beyond which no part of the equipment shall project. Allowance to be made by equipment manufacturer for new equipment for wear on journals and brasses, on axle collars, on rail, on wheels, compression of springs, sagging of center of car, constructional variations, end play, broken springs, etc.

Third-Rail Gage.—Distance, measured parallel to plane of top of both running rails, between gage of running rail and center line of third rail.

HISTORICAL.

With the adoption of electric traction by railroads using steam equipment, the question of what would constitute safe clearance lines for locating third-rail structures and overhead working conductors immediately presented itself. Most of the roads using steam equipment constructed their third rail so that it would clear the existing equipment, but it was deemed advisable also to fix a limit so that new equipment should not be built to encroach on the space occupied by third rail. Each road could adopt such equipment clearance lines as would meet its requirements, but this would not prevent complications in regard to interchange of foreign equipment, and therefore the American Railway Association appointed a Committee to establish recommended clearance lines for both third-rail structures and for equipment. This Committee recommended and the Association adopted certain lines which are shown on one of the diagrams included in this report. Since then the question of modifying or changing these lines has been agitated and a Sub-Committee of the Committee on Electricity submits the following report dealing with the clearance of third-rail structures and equipment clearance in the vicinity of such structures, leaving the question of clearances for overhead working conductors to be considered later.

RECOMMENDATIONS.

We have obtained, from all the principal railroads in this country using third rail, diagrams showing the outlines of the construction of their third-rail structures and from some of the principal steam railroads diagrams showing the outline of maximum equipment. These diagrams are illustrated in this report and were obtained as a basis for establishing clearance lines for both third-rail structures and equipment, beyond which lines, under no conditions, structures or equipment should be allowed to pass. This study of existing third-rail structures, together with the clearance lines adopted by the American Railway Association, has led us to recommend the attached diagram, entitled "Recommended Clearance Lines for Equipment and Third-Rail Structures, submitted by the Committee on Electricity."

The table, included in this report, has been prepared from the information received from the various companies represented, with a view of ascertaining what mileage of track of roads using steam equipment and third rail will clear the proposed lines. From this it will be noted that of a total mileage of 1,357.48 using steam equipment, 872.48 miles will clear the proposed lines. Those not clearing are mainly interurban electric roads which handle steam equipment as a secondary traffic.

Owing to the overhang of equipment passing around curves, it is advisable to change the lines adopted by the American Railway Association so that the limits shown on attached sheet will be applicable in all cases where the radius of curves is 800 ft. or less.

It has been the experience of steam railroads operating a portion of their territory by third rail that, in spite of rigid requirements that equipment be not allowed to extend beyond the line of maximum equipment, cars frequently have to be cut out of service in the electrified territory because of heavy loading, defective springs or other reasons causing the equipment to project beyond the limiting lines. Principally on account of this reason it is thought that the distance of one-half inch between the outline of maximum clearance for structures and the outline of maximum equipment is too small, and that if structures and equipment are allowed to approach so close there will be trouble from fouling in the event of adverse conditions. We have, therefore, recommended a distance of 1⅛ in. apart, for these two vertical and horizontal lines and a distance varying from $\frac{13}{16}$ in. to $\frac{15}{16}$ in. apart on the inclined part of the diagram which takes care of the side inclines at approaches to the curves, and specified that "equipment shall under no circumstances project beyond line of maximum equipment except as provided for on curves of 800 ft. radius and less. Structural variation, end play and wear of equipment shall be provided for by the equipment manufacturer inside this line.

A letter-ballot was taken on this report and a majority of the Committee is in favor of it. Mr. McHenry voted against the report as per the following letter:

"In response to yours of November 10, concerning third-rail clearances, I am unable to recommend any modifications of the existing clearances which would tend to further reduce such clearances. The conditions of the New Haven Road make it impracticable to accept for our company

DATA REGARDING THIRD RAIL CLEARANCES.

Revised October 17, 1910.

Name of Company	Plan No.	Top or Under Contact	Pro-tected	Uses Steam Equip-ment	Struc-tures Clear Prop. Lines	Mileage in Opera-tion	Mileage Planned for Immed. Future	Mileage Using Steam Equip-ment	Mileage Clearing Proposed Lines
Albany Southern	1	Top	No	Yes	No	52.00	......	52.00	......
Aurora, Elgin & Chicago	2	"	"	"	"	88.00	......	88.00	......
Baltimore & Ohio	3	"	Yes	"	Yes	8.70	......	8.70	8.70
Boston Elevated Ry	4	"	No	No	No	24.09	......	......	......
Brooklyn Rapid Transit	5	"	"	"	"	82.50	......	......	......
Northwestern Elevated, Chicago	6	"	"	"	"	60.00	......	......	......
Central California Traction	7	Under	Yes	Yes	Yes	45.00	......	45.00	45.00
Grand Rapids, Grand Haven & Muskegon	8	Top	No	No	No	41.26	......	......	......
Hudson & Manhattan	9	"	Yes	"	"	14.50	5.35	......	......
Interborough Rapid Transit	10, 11, 12	"	Partly	"	"	199.94	......	......	......
Lackawanna & Wyoming Valley	14	"	No	Yes	"	44.00	......	44.00	......
Long Island R. R.	13, 18	"	Yes	"	Yes	147.50	......	147.50	147.50
Metropolitan West Side, Chicago	6	"	No	No	No	49.28	......	......	......
Michigan United	16	"	"	Yes	"	82.00	......	82.00	......
Northern Electric Ry., Chico, Cal.	17	"	"	"	"	130.00	......	130.00	......
Penna. Tunnel & Terminal Co.	18	"	Yes	"	Yes	83.00	9.60	92.60	92.60
Puget Sound Electric Ry	19	"	No	"	No	37.50	......	37.50	......
Philadelphia & Western	20	Under	Yes	"	"	22.00	......	22.00	......
Scioto Valley Traction Co	21	Top	No	"	Yes	65.82	......	65.82	65.82
Southern Pacific R. R.	....	....	....	....	....	.....	139.00	......	......
*South Side Elevated, Chicago	6	"	"	No	No	46.41	......	......	......
West Jersey & Sea Shore	23	"	Yes	Yes	Yes	143.00	......	143.00	143.00
Wilkesbarre & Hazelton	24	"	"	"	No	29.50	......	29.50	......
N. Y. C. & H. R. R. R.	26	Under	"	"	Yes	131.40	114.20	245.60	245.60
N. Y. C. & H. R. R. R., Utica to Syracuse	25	"	"	"	"	105.76	......	105.76	105.76
Detroit River Tunnel Co	26	"	"	"	"	18.50	......	18.50	18.50
Phila. Rapid Transit Co	....	"	"	No	No	17.65	......	......	......
Totals						1,769.31	268.15	1,357.48	872.48

*Type not determined.

even the clearance already in use, as the third rail comes within the overlapping diagrams of equipment clearance and structural clearances. The third rail, accordingly, could not be adapted for use upon our system without creating the necessity for very heavy expenditures required for modifying our structures and rolling equipment.

"While these objections do not apply with equal force to the adoption of the proposed new standard clearance upon connecting lines with which our company interchanges cars, and upon which the structural clearances may not be so sharply limited, it is, nevertheless, in the opinion of our mechanical department, quite impracticable to further limit our equipment clearances.

"For the reasons above stated, I beg that you will register my adverse vote against the adoption of the report of the Sub-Committee."

Messrs. Drinker, Gibbs and Murray did not vote.

SUB-COMMITTEE NO. 2, TRANSMISSION LINE CROSSINGS.

The Sub-Committee has worked in conjunction with the National Electric Light Association and its progress report appears in Bulletin No. 127 of this Association.

SUB-COMMITTEE NO. 4, MAINTENANCE ORGANIZATION.

The following report was submitted by the Sub-Committee at the meeting held October 17, 1910:

This Sub-Committee was instructed to investigate and report on maintenance organization as affected by the introduction of electric traction. Five meetings, as follows, were held:

April 28, New York—Messrs. Austin and Dawley.

June 9, New York—Messrs. Austin, Lindsay and Dawley.

Sept. 8, New Haven—Messrs. Lindsay and McHenry.

Sept. 27, New York—Messrs. Austin, Lindsay and McHenry.

Oct. 3, Jamaica—Messrs. Austin and Lindsay.

The Sub-Committee has made no previous reports other than one of progress, and no subject has been presented in any report heretofore for discussion, nor have any of its recommendations been published in the Manual.

DEFINITIONS.

Electrical Supervisor.—An officer on the division staff qualified to supervise the maintenance of the electrical transmission and working conductors outside of the power station.

Bonders.—Employes qualified to maintain rail and other bonds and their appurtenances for all railroad voltages.

Traction Linemen.—Employes qualified to maintain wires and cables and their appurtenances.

Patrolmen.—Employes qualified to inspect and make minor repairs to track and third-rail structures, cables and wires, and to use hand signals for the protection of trains.

HISTORICAL.

The history of the electrification of steam railroads shows that railroads were confronted with the problem of either creating a new organization for the design, construction and installation of the apparatus in connection with electric propulsion or the enlargement and extension of the existing organization. When the installation was completed the question arose as to whether the construction organization should be continued for maintenance purposes or the hitherto existing maintenance organization enlarged or modified to meet the new conditions and maintain the additional appliances. This problem has been met in various ways by various roads. The history of this will be found in the bibliography in the body of the General Committee's report. While nearly all of the existing organizations have some merit and some warrant by the conditions existing on each particular road, the ideal organization has probably not as yet been perfected. We present for consideration and discussion the following:

ANALYSIS.

This Sub-Committee sent out, in connection with Sub-Committee No. 6, the following circular of inquiry:

"In order to assist the Committee on Electricity of the American Railway Engineering and Maintenance of Way Association to study electric traction and transmission as affecting the design, construction, operation and maintenance of railways, you are respectfully requested to furnish the information asked for below by the Sub-Committees on "Maintenance Organization" and "Relation to Track Structures."

"(1) Give a brief history of the installation of electricity for traction purposes on your road, giving dates, etc., and reference to any publications on it that may have appeared.

"(2) Has your maintenance organization been modified by electrification? If so, please give outline both before and after, with successive changes and the reasons therefor.

"(3) Has the introduction of electric traction necessitated the shortening of the track sections or increasing of the track forces, and if so, to what extent?

"(4) Furnish copies of books of rules and special instructions relative to maintenance where electrified. What has been your experience of the effect of the presence of the third rail upon the efficiency of the track force?

"(a) Through fear of injury.

"(b) Through the physical obstruction to the free movement of the men in walking about the tracks and working on them.

"(c) By what per cent. has their efficiency been reduced by these causes?

"(5) What provisions have you for keeping your electrified line clear of snow, ice or sleet; especially the electrical contact rail or wire? Are your methods and devices satisfactory? If not, in what respect are they lacking?

"(6) Please furnish prints showing design of track or rail bonds in use for the return of negative current, indicating any changes in the design of angle bars, rail, or drilling of rails necessitated thereby.

"(7) Furnish prints showing design and location of reactance bonds with reference to track, and details of connection thereto.

"(8) Furnish prints showing design of underground ducts for transmitting positive current across gaps, showing relation to track, road crossings, etc.

With Third-Rail Type of Conductor.

"(1) What plan has been adopted to keep third rail away from platforms at passenger stations?

"(2) Is such precaution necessary?

"(3) Is the use of dummy third rail on platform side advisable?

"(4) Please furnish print showing relation of third rail to platform and modifications of platform design or construction necessitated thereby.

"(5) What precautions have been necessary in the location of third rail with reference to the running rails, or as to the windward or leeward sides of the track, to avoid snow troubles?

"(6) What has been your experience as to the unequal loading of the ties due to the presence of the third rail affecting track level?

"(7) What changes has the presence of the third rail necessitated in the methods of track work, such as renewing ties, relaying rails, spiking, gaging, surfacing, lining, etc.?

"(8) Has the presence of the third rail prohibited or abridged the use of lever cars, push cars, velocipedes, etc.?

"(9) What changes have been necessitated by the presence of the third rail in the unloading of rail, frogs, switches and other heavy material formerly dropped from cars?

"(10) Please furnish prints showing location of third rail with reference to track on double, three and four track layouts.

"(11) Please furnish prints showing third-rail layout at switches, turnouts, crossovers, etc.

"(12) What means of furnishing current supply to equipment is necessary at gaps in third rail?

"(13) Please furnish print showing relation of third-rail structure to cattle guards.

With Overhead Type of Conductor.

"(1) Please furnish prints showing method of attachment to overhead bridge structures.

"(2) Furnish prints showing method of providing bridge alarms for low structures.

"(3) Furnish prints showing location of conductor in tunnels.

"(4) What effect has the overhead conductor had upon signal location and what has been your solution of the problem?

With Either Type of Conductor.

"(1) What method has been adopted to provide continuous supply and return circuits at draw and lift bridges, and what precautions have been necessary to prevent injury to such structures or interference with their operation?

"(2) What precautions have been necessary to protect steel structures from damage by short circuit?

"(3) What has been the effect of electric equipment upon track?

"(a) Rail wear.

"(b) Line maintenance.

"(c) Surface.

"(d) Spikes and tie plates.

"(e) Joints.

"(f) Frogs and switches."

While many roads addressed did not reply, a sufficient number of replies were received to afford very interesting study with a view of reaching conclusions and making possible recommendations in the future. It was found that on one road the entire construction work, including the rearrangements of tracks and the building of power houses, sub-stations, transmission lines, third rail, equipment, etc., was done under the direction of a new organization, separate and distinct from either the construction or maintenance organization on the railroad, the work being done by contract or by company forces under the direction of its new staff, working as closely as possible in harmony with the existing maintenance and operating organizations. When the plant was ready for operation separate organizations were created for the maintenance of equipment, power houses and transmission lines, and for third rail and appurtenances. This was subsequently modified so that these three separate organizations were brought under the jurisdiction of the operating department, which already had jurisdiction over the maintenance of track and other structures.

In a second case, while a new organization was created to design and supervise the installation, much of the work was performed by the existing construction department, and after the work was finished the maintenance was assigned to existing branches of the service which were enlarged and modified to meet the new conditions.

In a third case a special engineering organization was created to design the installation and to supervise the construction work. All plans were prepared by or under the direction of this organization, which also awarded contracts for the different parts of the work. A large contract covering the erection of the catenary bridges and overhead system was awarded to an electrical manufacturing company on the basis of cost plus percentage.

Other contracts covering the power house, catenary bridge foundations and bonding were awarded to other contracting firms.

When the installation was in readiness for operation it was turned over to the regular general and divisional operating and maintenance forces, supplemented by the appointment of an Electrical Superintendent, a Chief Engineer of the power house and a Master Mechanic in special charge of electric engines.

In yet another case the installation was designed by a separate organization created for that purpose, but the work was performed under the supervision of this staff by the existing maintenance organization, and at the completion of it was maintained by this same organization.

A study of these and other similar cases in the electrification of steam railways brings the Sub-Committee to the conclusion that the maintenance organizations created when electricity was submitted for steam propulsion can now be modified in the light of some few years' actual experience and along the lines shown on exhibit "A."

It is the intent to make this skeleton organization elastic enough to serve for roads having either a divisional or departmental organization, but it is not intended to show a complete maintenance of way organization in any case, the details of the organization itself only being shown in the cases of employes whose duties pertain to or are affected by the maintenance of apparatus for electric propulsion.

The Sub-Committee believes that the officer in general charge of maintenance of way of a railroad operated by steam or electricity, or both, is, or should be, fully equipped to superintend the maintenance of the various appliances that have been introduced in connection with electrical installation, but should have on his staff an electrical engineer, or be able to consult with one.

Similarly, the division officer in charge of maintenance of way should have on his staff a man with sufficient knowledge of electricity peculiar to the installation that will enable him to inspect the work of maintenance performed by the department.

The maintenance of towers or bridges for the support of transmission lines being work of no different nature from that actually performed by the bridge men, there is no reason why it cannot be done under the supervision of the head of the bridges and building forces. The maintenance of the buildings occupied as power houses, sub-stations, battery houses, circuit-breaker houses and cable terminals is such as is usually done by the building department, and there is no reason for this work being done by any other or by any special department, the only unusual condition being the presence, in some cases, of transmission lines carrying electric current of high voltage, and there is no difficulty in educating men erecting, repairing, painting, etc., around these transmission wires to take the necessary precautions for their safety and for preventing the interruption of the service. The maintenance of aerial cables, wires, suspension bridges of the catenary type composed of wires involves no special knowledge or training that the man in charge of the maintenance of bridges and buildings should not possess. The only care being necessary is to educate the traction linemen actually employed in the work in protecting themselves against personal injuries from high-tension currents and taking the necessary precautions to avoid interruption to the service. This applies with equal force to roads having the third-rail type of contact or the overhead type of contact.

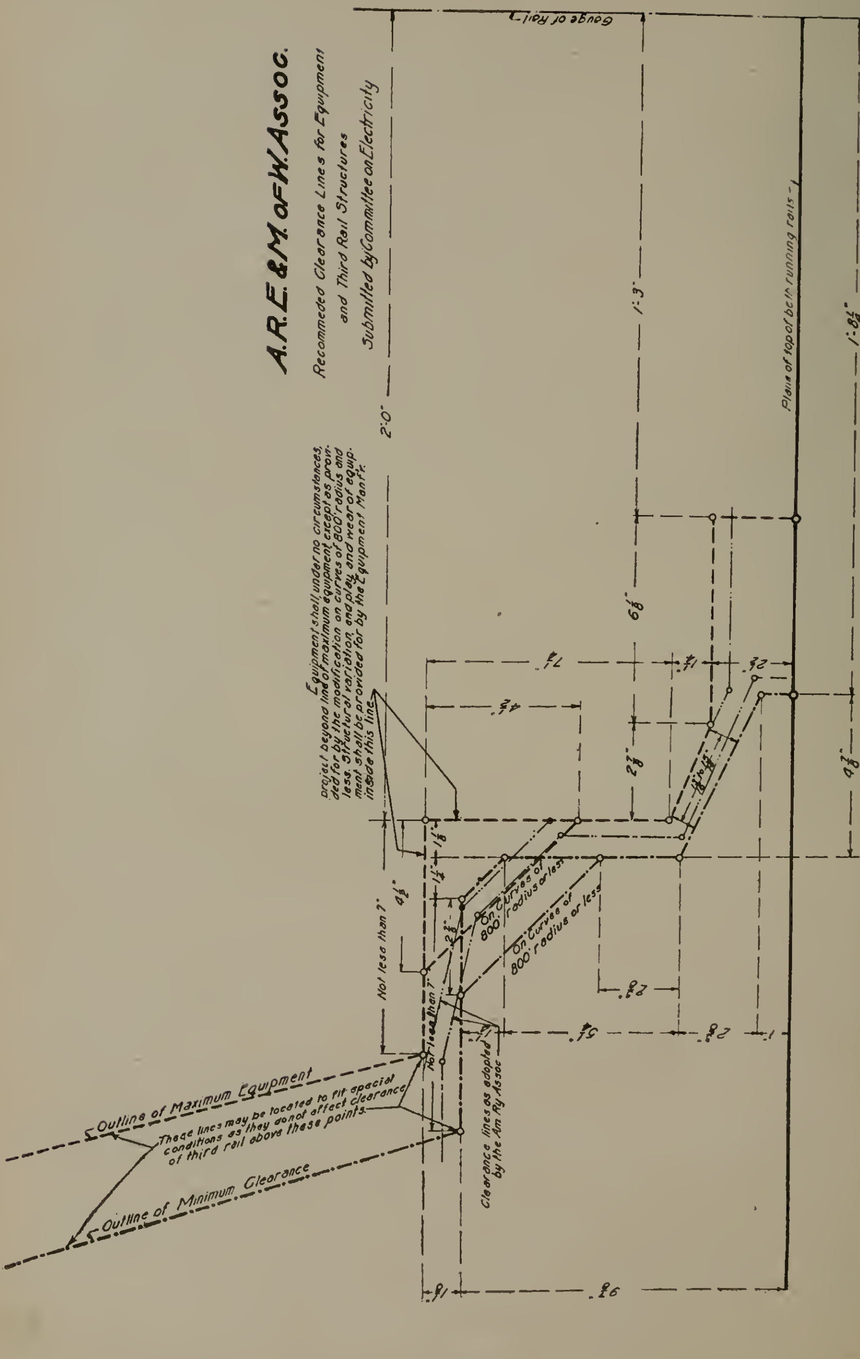

A.R.E.&M. of W. Assoc.
Recommended Clearance Lines for Equipment and Third Rail Structures
Submitted by Committee on Electricity
Gauge of Rail
Plane of top of both running rails
Equipment shall under no circumstances project beyond line of maximum equipment except as provided for by the modification on curves of 800' radius and less. Structural variation and play and wear of equipment shall be provided for by the Equipment Man'f'r. inside this line.
Outline of Maximum Equipment
These lines may be located to fit special conditions as they do not affect clearance of third rail above these points.
Outline of Minimum Clearance
Clearance lines as adopted by the Am. Ry. Assoc.
On Curves of 800' radius or less
On Curves of 800' radius or less
Not less than 7"
Not less than 7"
2'0"
1'3"

DIAGRAM B.

The work of maintaining third rail and appurtenances and track bonds is so closely associated with the work of maintaining track that the section foreman is the logical and proper man to be in charge of all such work on any particular section. The bonds, being usually of the concealed type, necessitate the removal of the joints before they can be inspected or repaired; the third rail is usually supported on the track structure and is in intimate relation with it so that repairs to the one usually involves repairs to the other, demanding the presence of the section forces, and therefore the section foreman should be the man in control. These remarks apply with equal force to the removing of snow, ice or other obstructions. In yards and at other congested points where there is a number of tracks the work of bond maintenance may be of sufficient amount to warrant having bonders on the section forces, or may be sufficiently great to warrant the organization of an extra gang of bonders, working under an extra gang foreman under the control of the supervisor of track, or, in the event of stretches of territory where the work of bond maintenance would not warrant the employment of a man on each section for that purpose, it could be cared for by bonders under the direct supervision of the supervisor of track, these men to work under the immediate supervision of the section foreman while on his territory.

The work of the patrolman which, on some roads, has been devoted exclusively to the inspection and minor repair of third rail and its appurtenances, is closely associated with that of the trackwalker, and there is no reason why one man could not perform the duties of both and also give such attention as may be necessary to the mechanical inspection of aerial wires and cables, territories being so arranged as to be reasonably within the physical capacity of the patrolman and so as to give inspection sufficiently often to safeguard traffic and avoid delay thereto.

The electrical supervisor above mentioned who reports to the division officer in charge of maintenance is understood to exercise general supervision over all the electrical work done by the supervisor of track and the officer in charge of bridges and buildings, with a view to securing adherence to standards and proper methods of work, principally from an electrical standpoint.

The Committee wishes to emphasize one important feature of this proposed organization, namely, the fact that the classification of expense accounts as established by the Interstate Commerce Commission and by various State Commissions places in the maintenance of way the expense of maintenance of transmission lines, contact lines, power houses, etc., so that it seems to be exceedingly logical that the actual supervision of the work of maintenance should be done under the supervision of the maintenance of way organization.

In conclusion the Sub-Committee recommends:

(1) The adoption of the definitions given for Electrical Supervisor, Bonders, Traction Linemen and Patrolmen.

(2) That the work of maintenance should be done as far as possible by the existing maintenance of way organizations, with such modifications as may be necessary for the special work involved in the electrification.

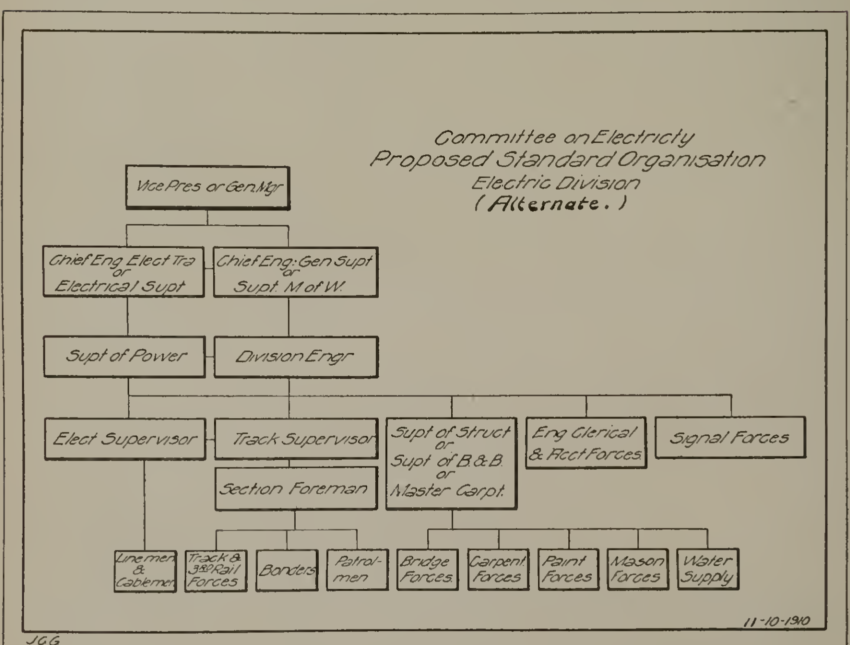
(3) That a Maintenance of Way Organization, as shown on exhibit attached, will be productive of efficient results.

(4) That these recommendations be printed in the Manual.

A letter-ballot was taken on this report and a majority of the Committee is in favor of it. Messrs. Drinker and Gibbs did not vote. Mr. Katte objected to the report and commented as follows:

"I have yours of the 7th transmitting report of Sub-Committee No. 4 on the subject of Maintenance Organization, and after having carefully considered its contents would suggest the following for the consideration of the General Committee:

"On the sixth page the second paragraph opens with the following sentence: 'The maintenance of towers or bridges for the support of transmission lines being work of no different nature from that actually performed by the bridge men, there is no reason why it cannot be done under the supervision of the head of the bridges and building forces.' I disagree with this statement and believe that under no circumstances should other than qualified high-tension linemen be permitted to work above a point a few feet below the transmission line insulators, except when all circuits carried by the supporting structure are 'killed.' The same paragraph contains the following: 'The maintenance of aerial cables, wires, suspension bridges of the catenary type composed of wires involves no



special knowledge or training that the man in charge of the maintenance of bridges and buildings should not possess.' Again I disagree with the Committee, believing that the cables, insulators, etc., should be maintained only by linemen qualified for this class of work, and this opinion is expressed after sad experience.

"Referring to the proposed standard organization sheet for Electric Divisions, I do not believe it proper to place Linemen under the Master Carpenter or similar officer, but think these forces should report direct to the Electrical Supervisor. I also note that although the words 'including supply of power' are mentioned, there is no division officer charged with this duty.

"I am attaching a tracing of a suggested alternate organization in which the Superintendent of Power is closely related with the Division Engineer, and the Electrical Supervisor closely related with the Track Supervisor, and it will be noted that the Superintendent of Power in this suggested organization is responsible for handling high-tension conductors and there is no division of responsibility between power stations, transmission lines, sub-stations and the delivery of power to the third rail.

"While I think it proper to discuss general forms of organization, I do not think we have yet reached a stage where any standard form can be proposed which will be suitable for all steam railroads which have electrified divisions."

SUB-COMMITTEE 6, RELATION TO TRACK STRUCTURES.

The following report was received from this Sub-Committee at the meeting held October 17:

"This Sub-Committee was instructed to investigate and report upon the relation of the various appliances necessitated by the introduction of Electric Traction to the existing track structures. Five meetings were held as follows:

April 28, New York—Messrs. Austin and Dawley.
June 9, New York—Messrs. Austin, Lindsay and Dawley.
September 8, New Haven—Messrs. Lindsay and McHenry.
September 27, New York—Messrs. Austin, Lindsay and McHenry.
October 3, Jamaica—Messrs. Austin and Lindsay

The Sub-Committee has made no previous reports other than of progress, and no subject has been presented in any report before for investigation, nor have any of its recommendations been published in the Manual.

DEFINITIONS.

Bond.—A metallic means for connecting two rails to permit of passage of electric current.

Cable.—A rope composed of wires for the transmission of electricity.

HISTORICAL.

The history of the various appliances for electric propulsion affecting track structure will be found in the bibliography in the body of the General Committee's report.

ANALYSIS.

The Sub-Committee sent out, in connection with Sub-Committee No. 4, a circular of inquiry which is quoted in full in that Sub-Committee's report. Such reports as have been received are satisfactory, but the Sub-Committee has not received reports from many of the roads on which electric propulsion has been introduced, so that it does not feel warranted in drawing conclusions at this time.

RECOMMENDATIONS.

(1) That the definition of bond and cable be adopted.

(2) That the Committee continue its investigations along the lines outlined in the circular of inquiry.

A letter-ballot was taken on this report and a majority of the Committee is in favor of it."

CONCLUSIONS OF THE WHOLE COMMITTEE.

(A) The Committee recommends for adoption by the Association:

(1) DEFINITIONS.

Third-Rail Clearance Lines.—Lines beyond which no part of the third-rail structure shall project.

*Equipment Clearance Lines.—Lines beyond which no part of the equipment shall project. Allowance to be made by equipment manufacturer of new equipment for wear on journals and brasses, on axle collars, on rail, on wheels, compression of springs, sagging of center of car, constructional variations, end play, broken springs, etc.

*Third-Rail Gage.—Distance, measured parallel to plane of top of both running rails, between gage of running rail and center line of third rail.

*Electrical Supervisor.—An officer on the division staff qualified to supervise the maintenance of the electrical transmission and working conductors outside of the power station.

Bonders.—Employés qualified to maintain rail and other bonds and their appurtenances.

Traction Linemen.—Employés qualified to maintain wires and cables and their appurtenances for all railroad voltages.

Patrolmen.—Employés qualified to inspect and make minor repairs to track and third-rail structures, cables and wires, and to use hand signals for the protection of trains.

Bond.—A metallic means for connecting two rails to permit of passage of electric current.

Cable.—A rope composed of wires for the transmission of electricity.

(2) The lines shown on diagram B (see report of Sub-Committee No. 1) as third-rail clearance lines.

(3) The lines shown on diagram B (see report of Sub-Committee No. 1) as equipment clearance lines.

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*See amendments, page 165.

(4) The principle that electric maintenance should, as far as possible, be performed by existing Maintenance of Way Organization with such modifications as may be necessary.

(5) A Maintenance of Way Organization, shown on diagram A, will be productive of efficient results.

(B) The Committee submits as information with request for printing in the Proceedings:

(1) Report of Clearances—Sub-Committee No. 1.
Report of Transmission Line Crossings—Sub-Committee No. 2.
Report of Maintenance Organization—Sub-Committee No. 4.
Report of Relation to Track Structures—Sub-Committee No. 6.

(C) The Committee reports progress on
Insulation and protection.
Electrolysis.

(D) The Committee recommends a continuation of work already outlined and asks for such other direction or instruction as seems necessary or desirable.

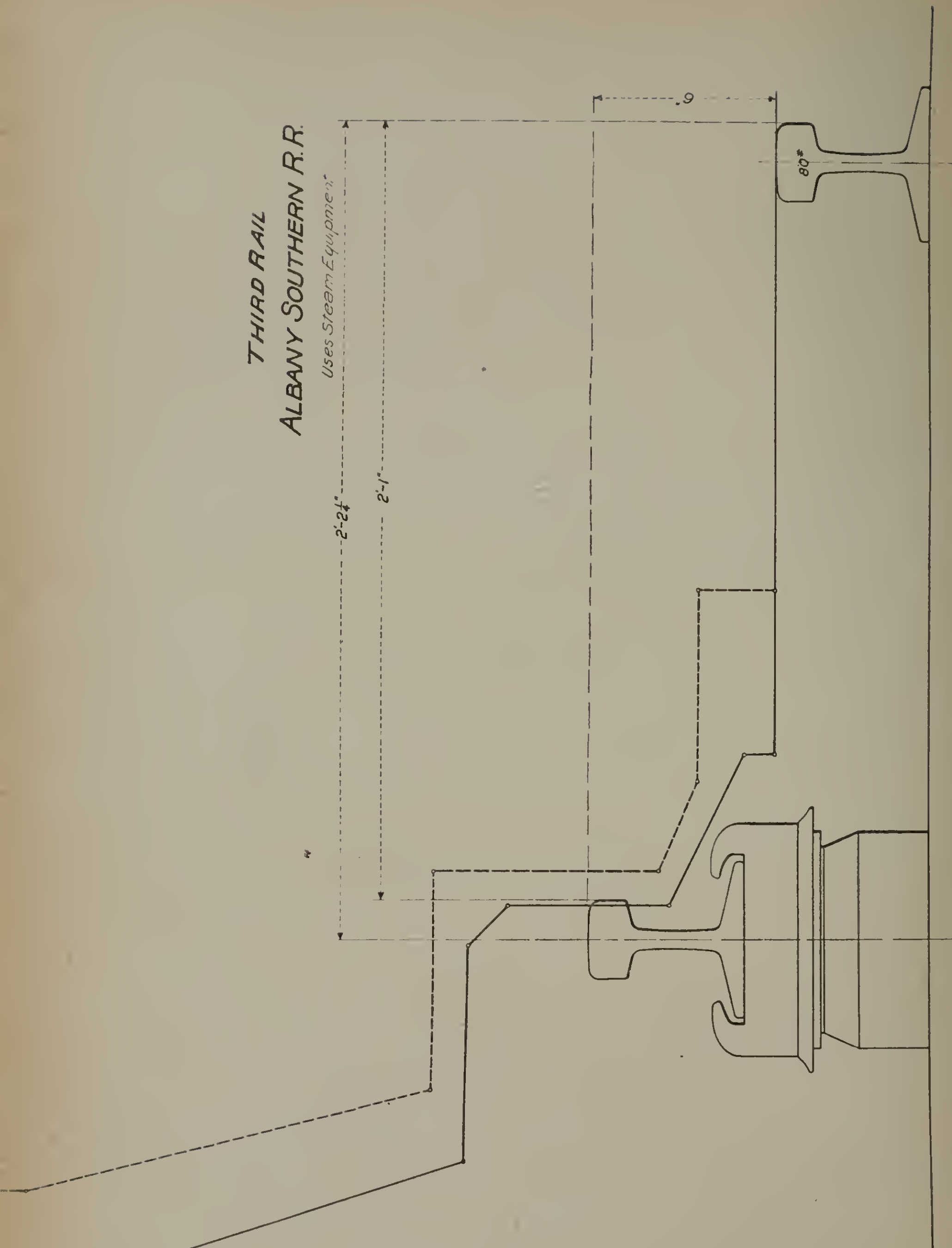
Respectfully submitted for the Committee by

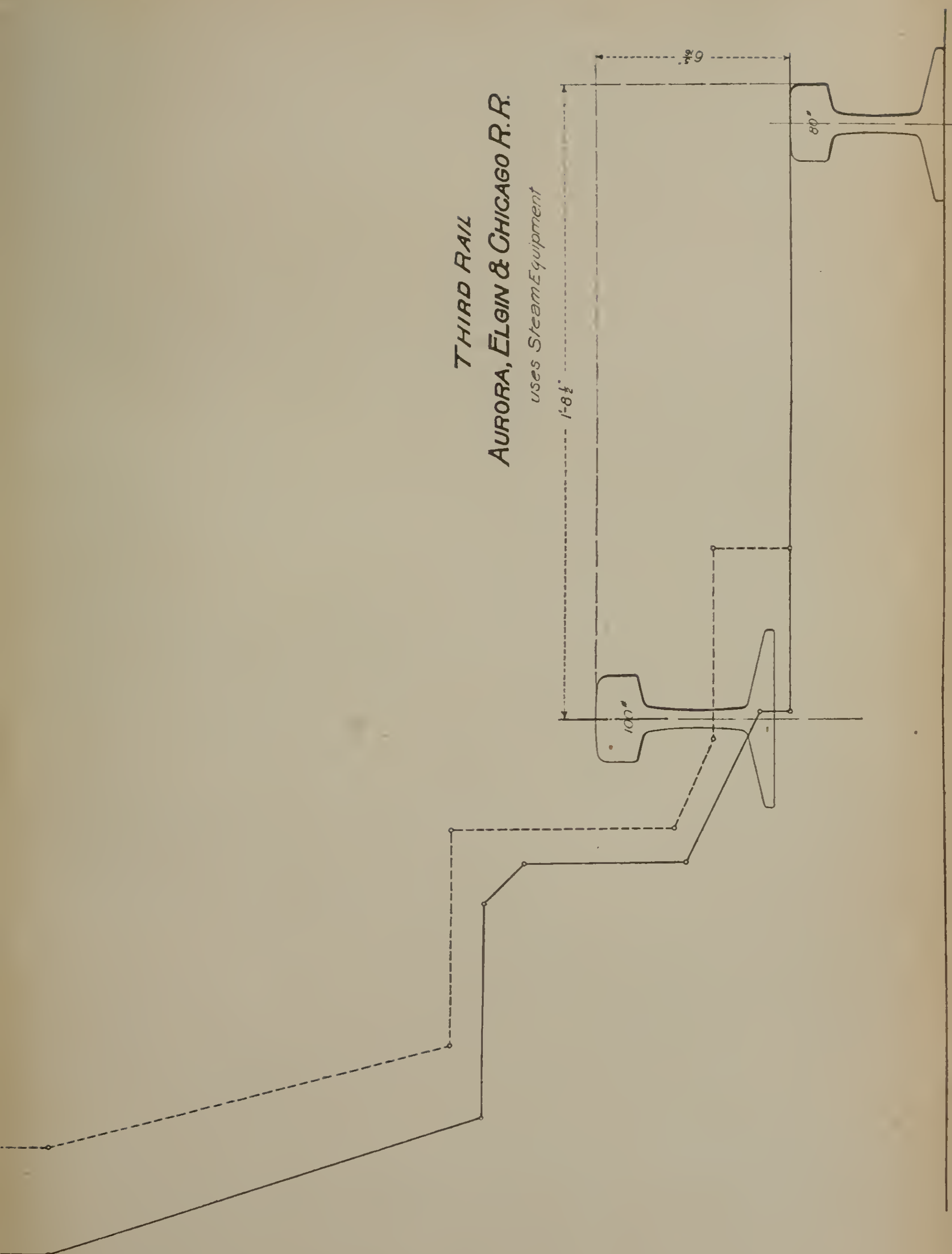
GEORGE W. KITTREDGE, *Chairman.*

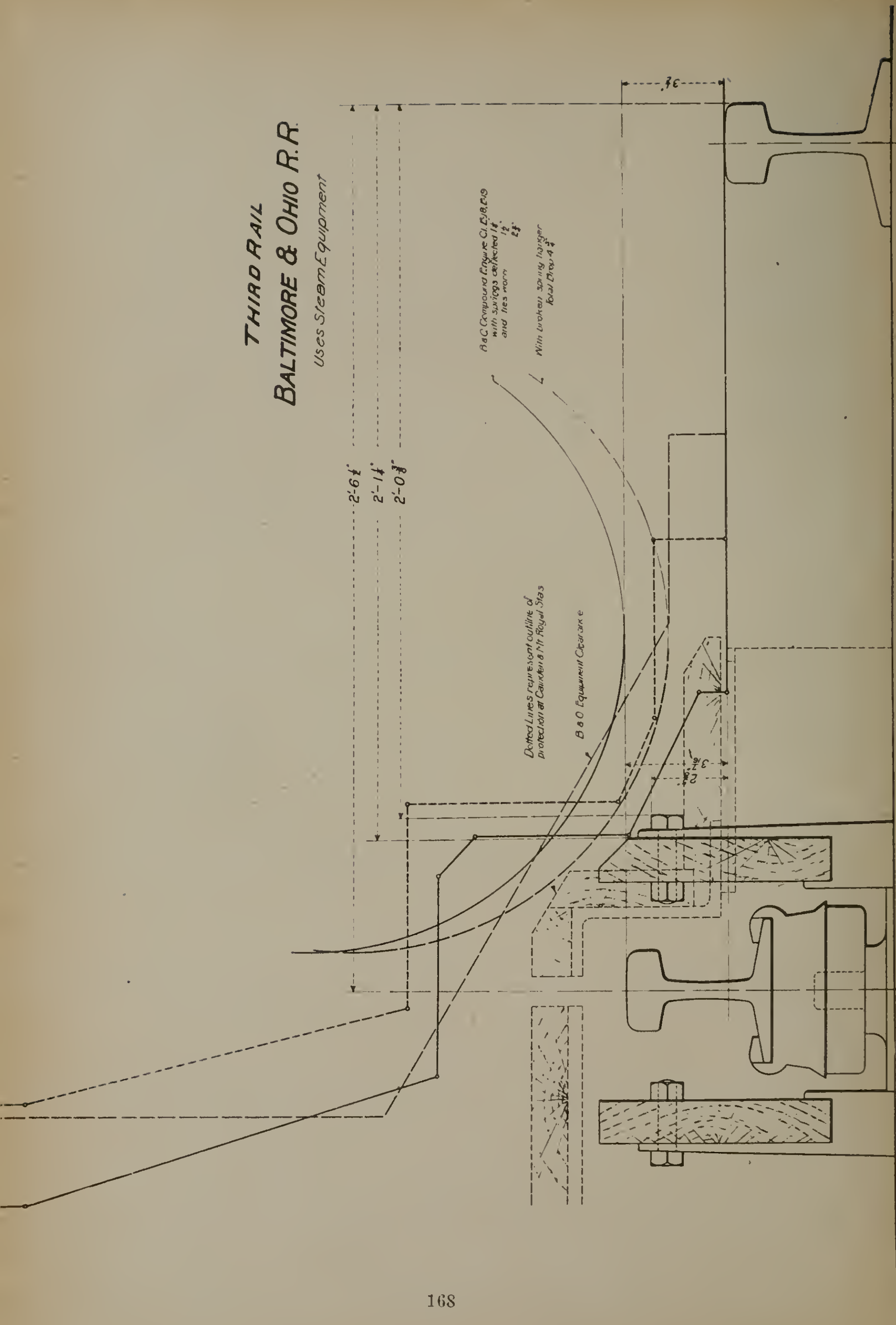
AMENDMENTS.

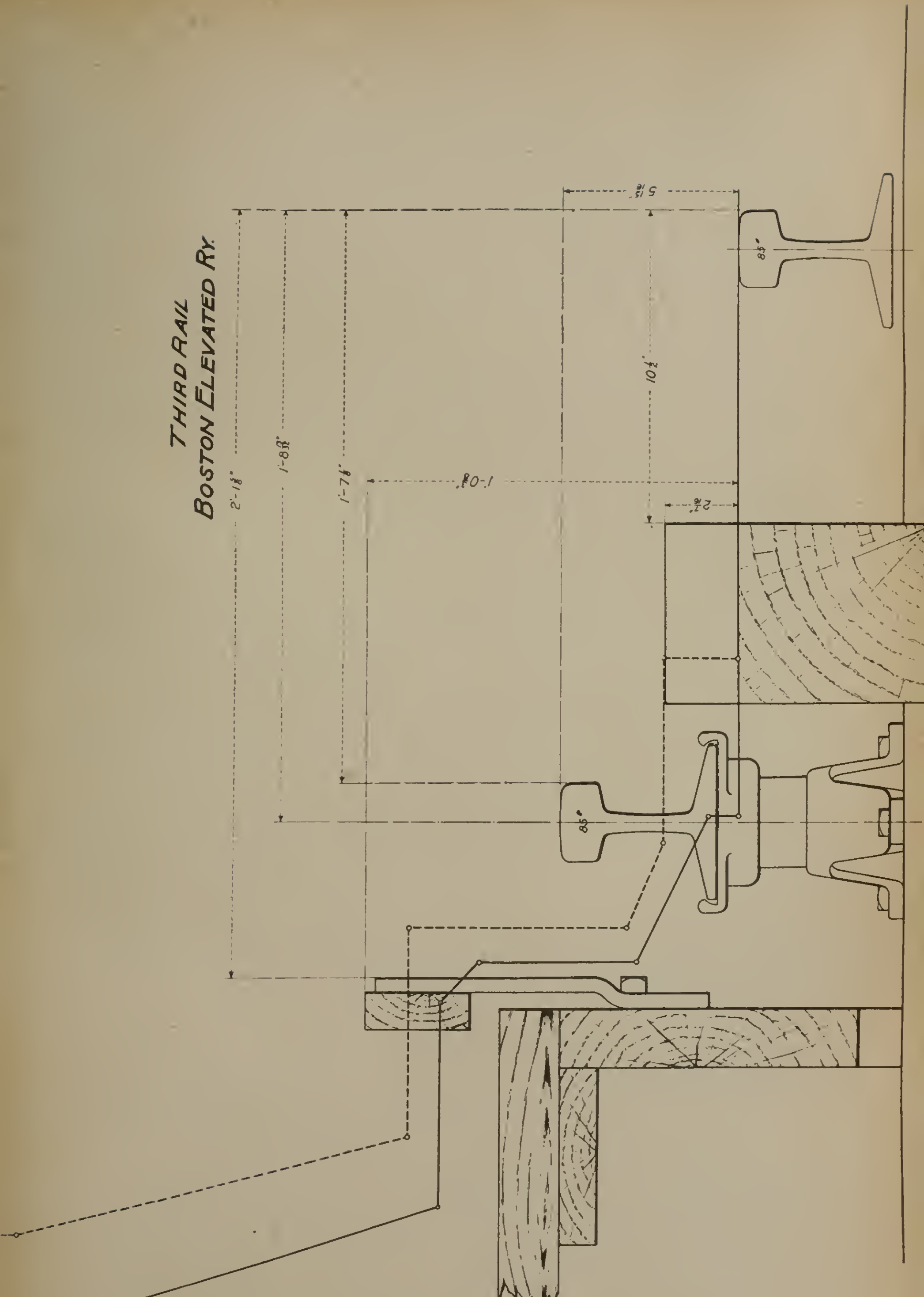
Amend definition for "Equipment Clearance Lines" to read as follows:

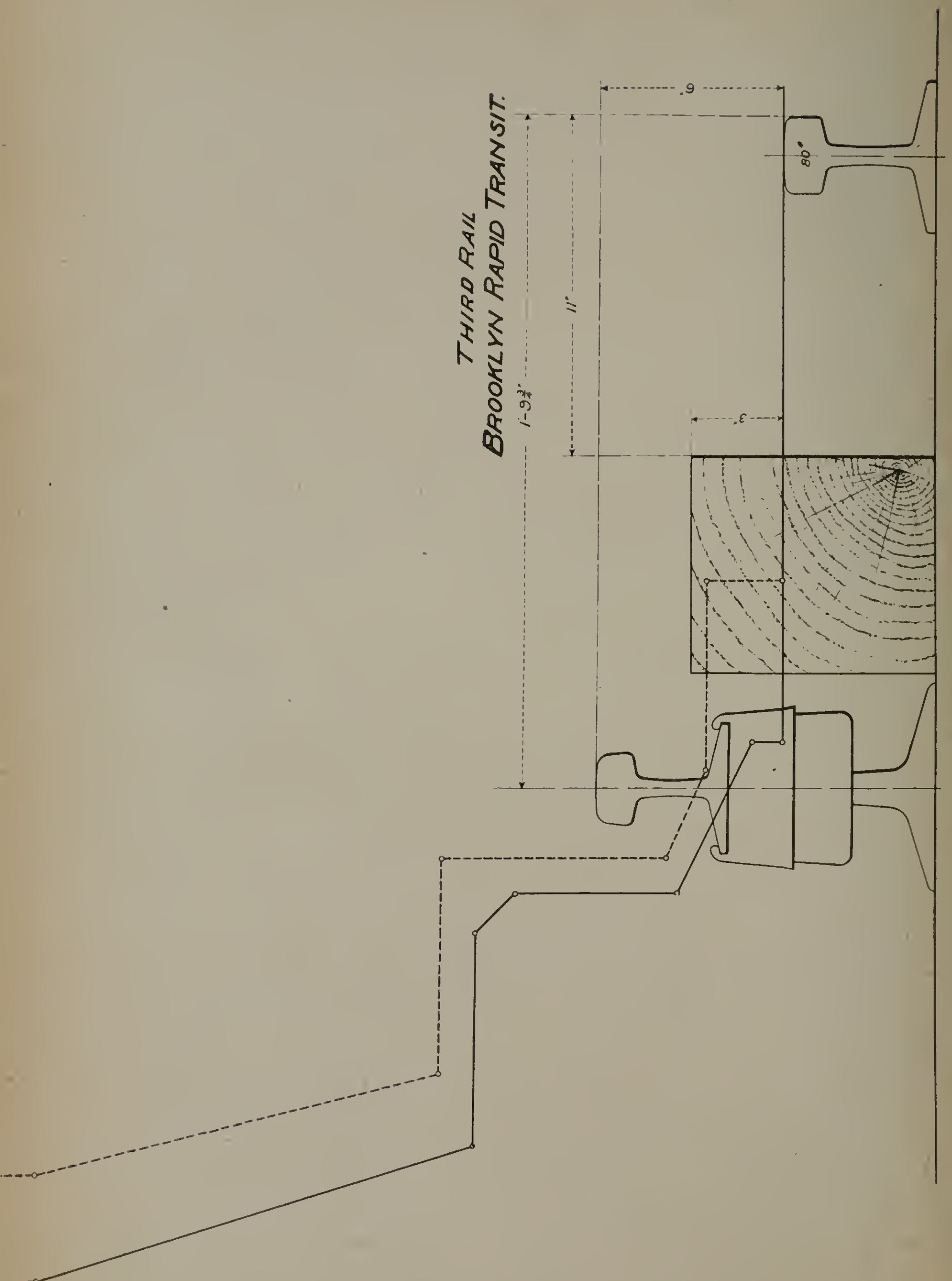
"Equipment Clearance Lines.—Lines beyond which no part of the equipment shall project. Allowance must be made by equipment manufacturer for new equipment for wear on journals and brasses, on axle collars, on rail, on wheels, compression of springs, sagging of center of car, constructional variations, end play, broken springs, etc."


THIRD RAIL
ALBANY SOUTHERN R.R.
Uses Steam Equipment
2'-2¼"
2'-1"
6"
80#


THIRD RAIL
AURORA, ELGIN & CHICAGO R.R.
uses Steam Equipment
1'-8½"
6½"
80#
100#


THIRD RAIL
BALTIMORE & OHIO R.R.
Uses Steam Equipment
B&O Compound Engine Cl. E18, E19
with springs deflected
and tires worn
With broken spring hanger
Total Drop
Dotted Lines represent outline of
protection at Camden & Mt Royal Stas
B & O Equipment Clearance
2'-6¼"
2'-1¼"
2'-0¾"


THIRD RAIL
BOSTON ELEVATED RY.


THIRD RAIL
BROOKLYN RAPID TRANSIT.
1-9¾"
11"
6"
3"
80°

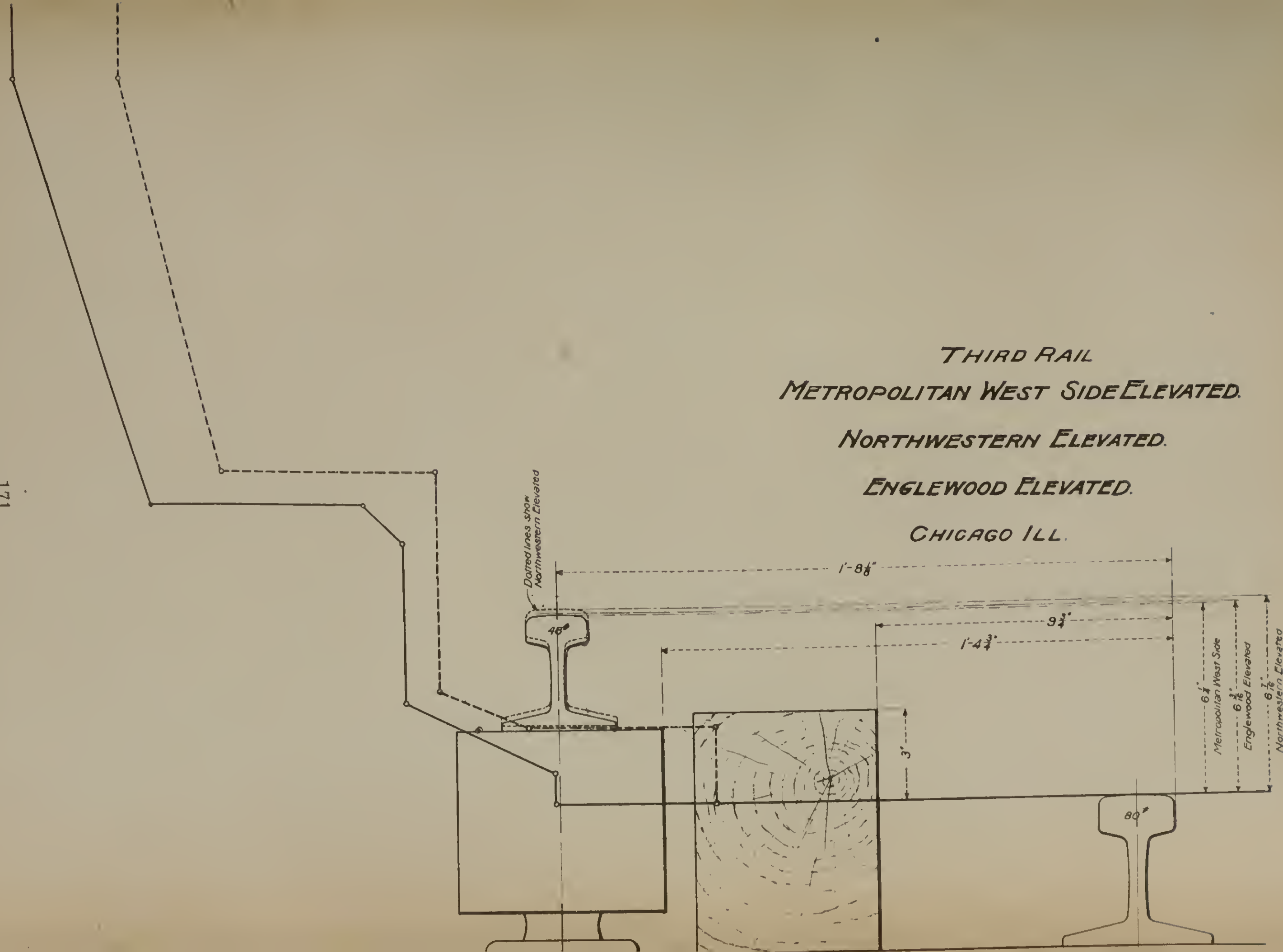
THIRD RAIL

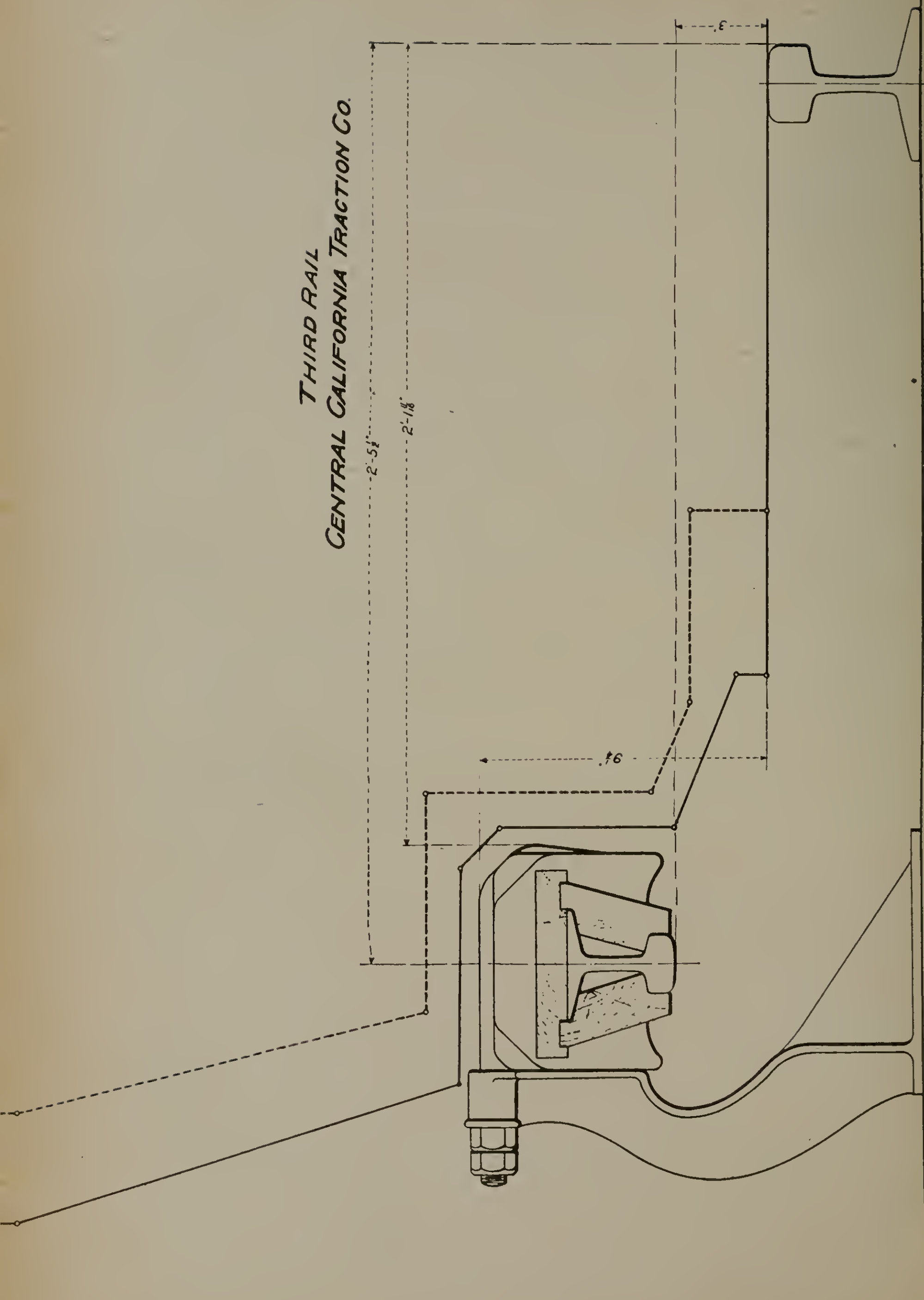
METROPOLITAN WEST SIDE ELEVATED.

NORTHWESTERN ELEVATED.

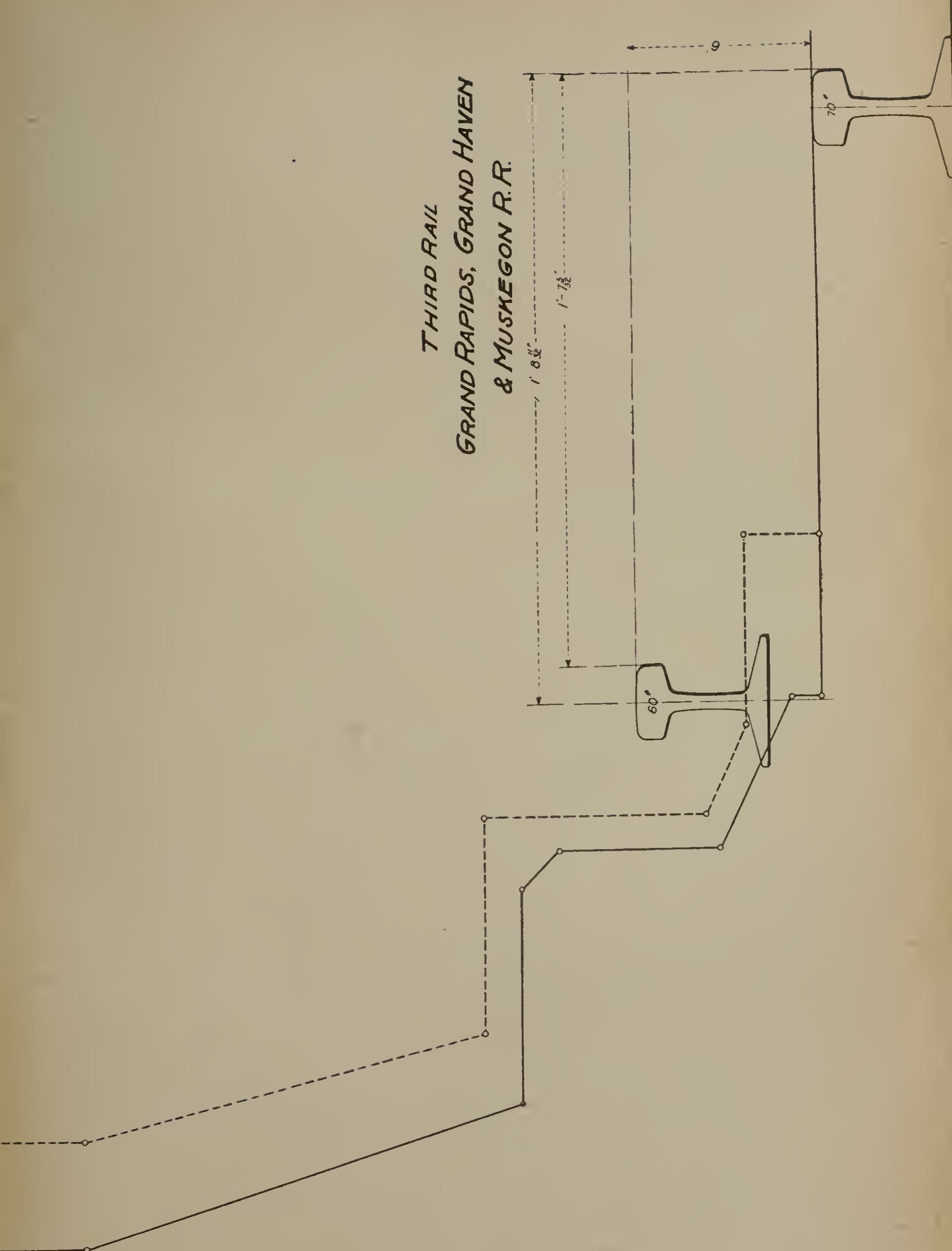
ENGLEWOOD ELEVATED.

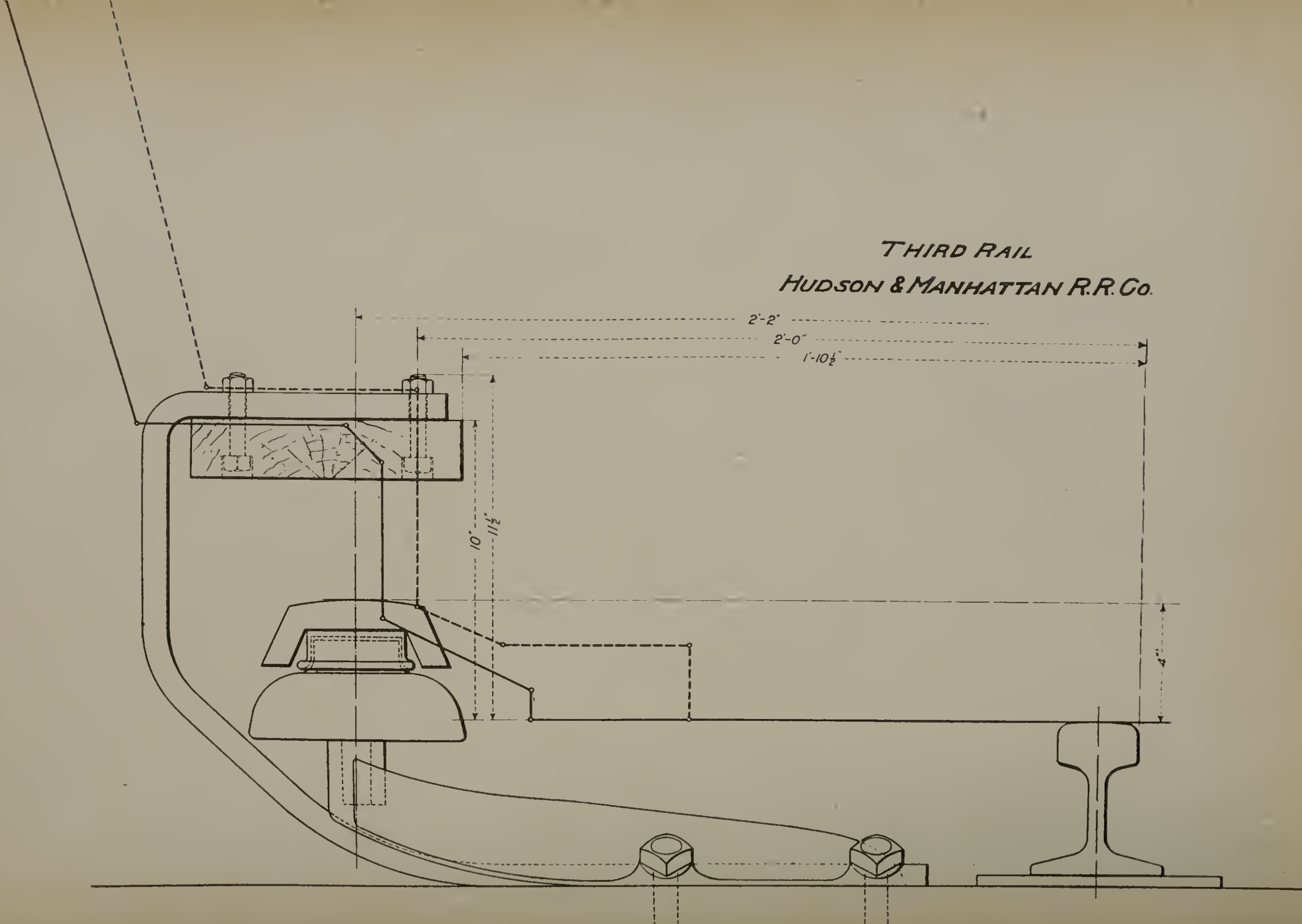
CHICAGO ILL.

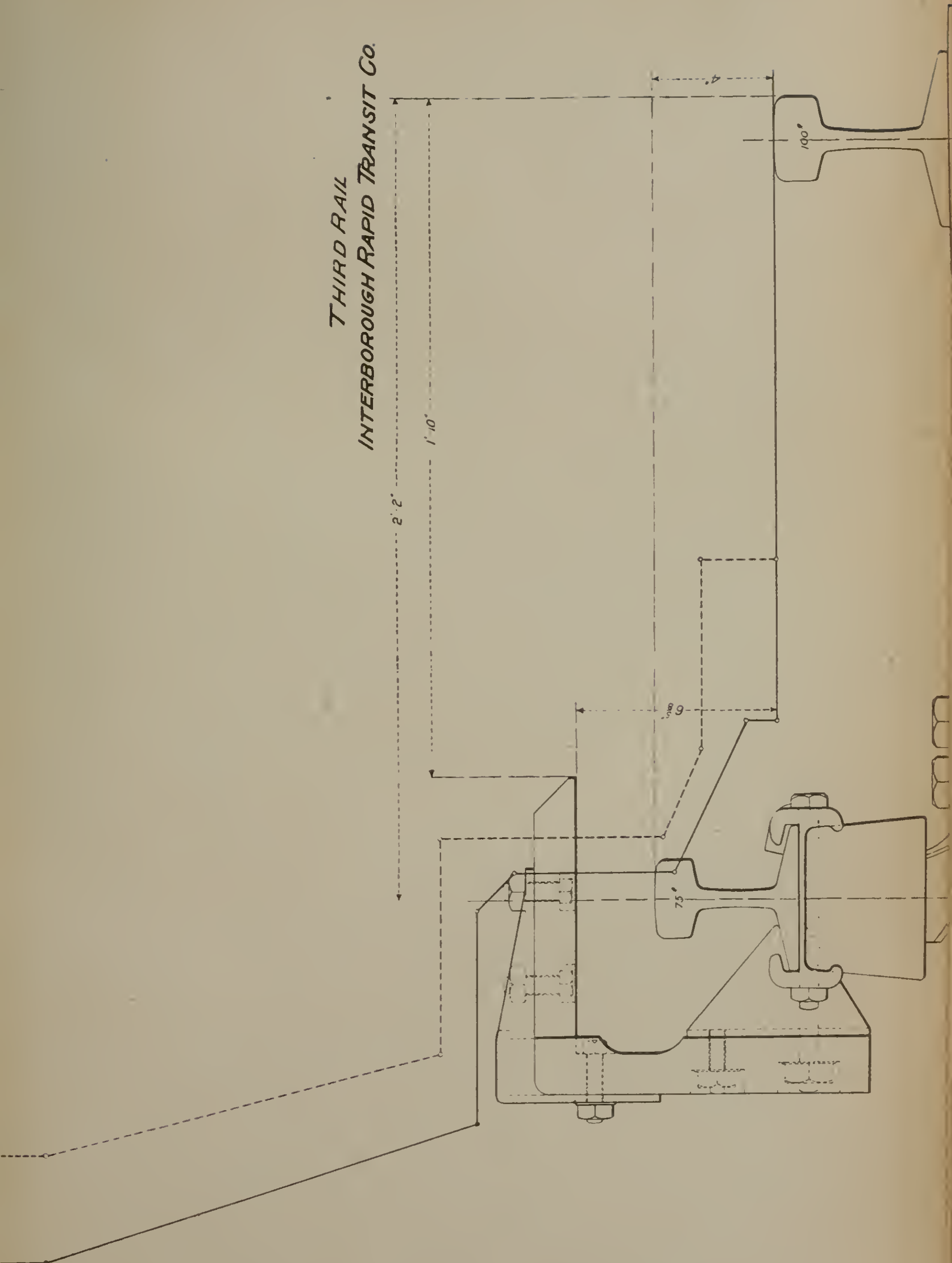


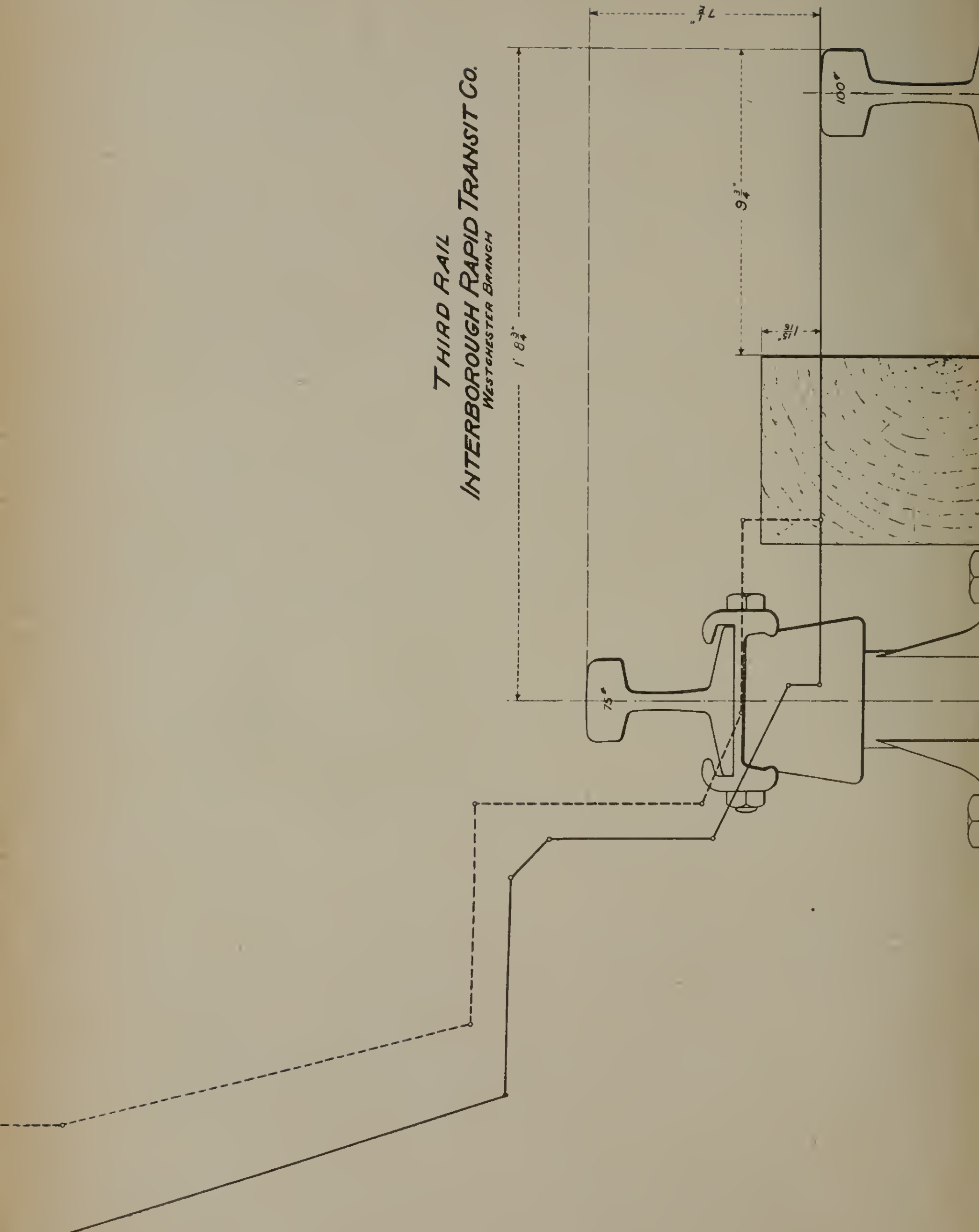


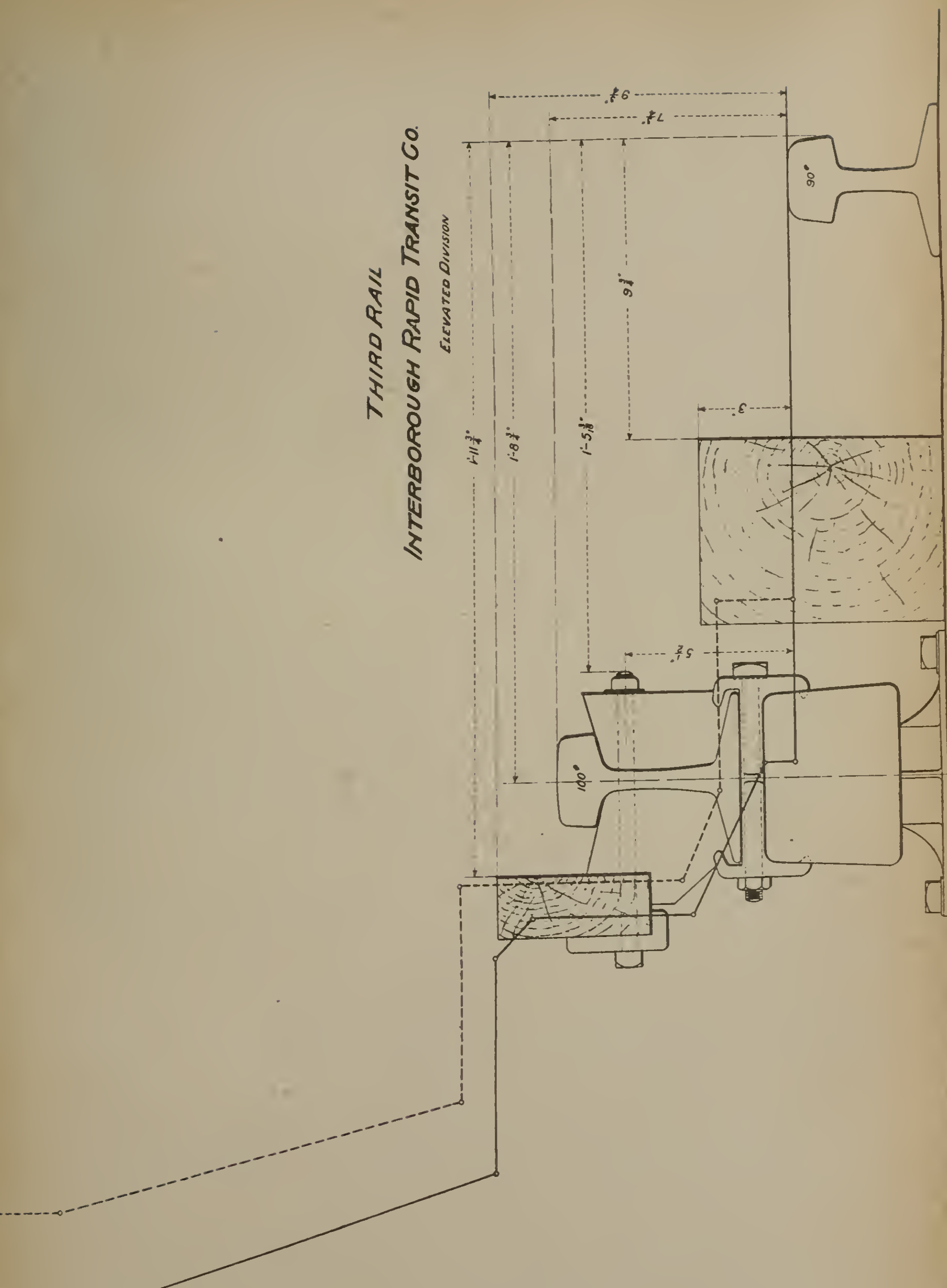
THIRD RAIL
CENTRAL CALIFORNIA TRACTION CO.


THIRD RAIL
GRAND RAPIDS, GRAND HAVEN
& MUSKEGON R.R.
9
70
60

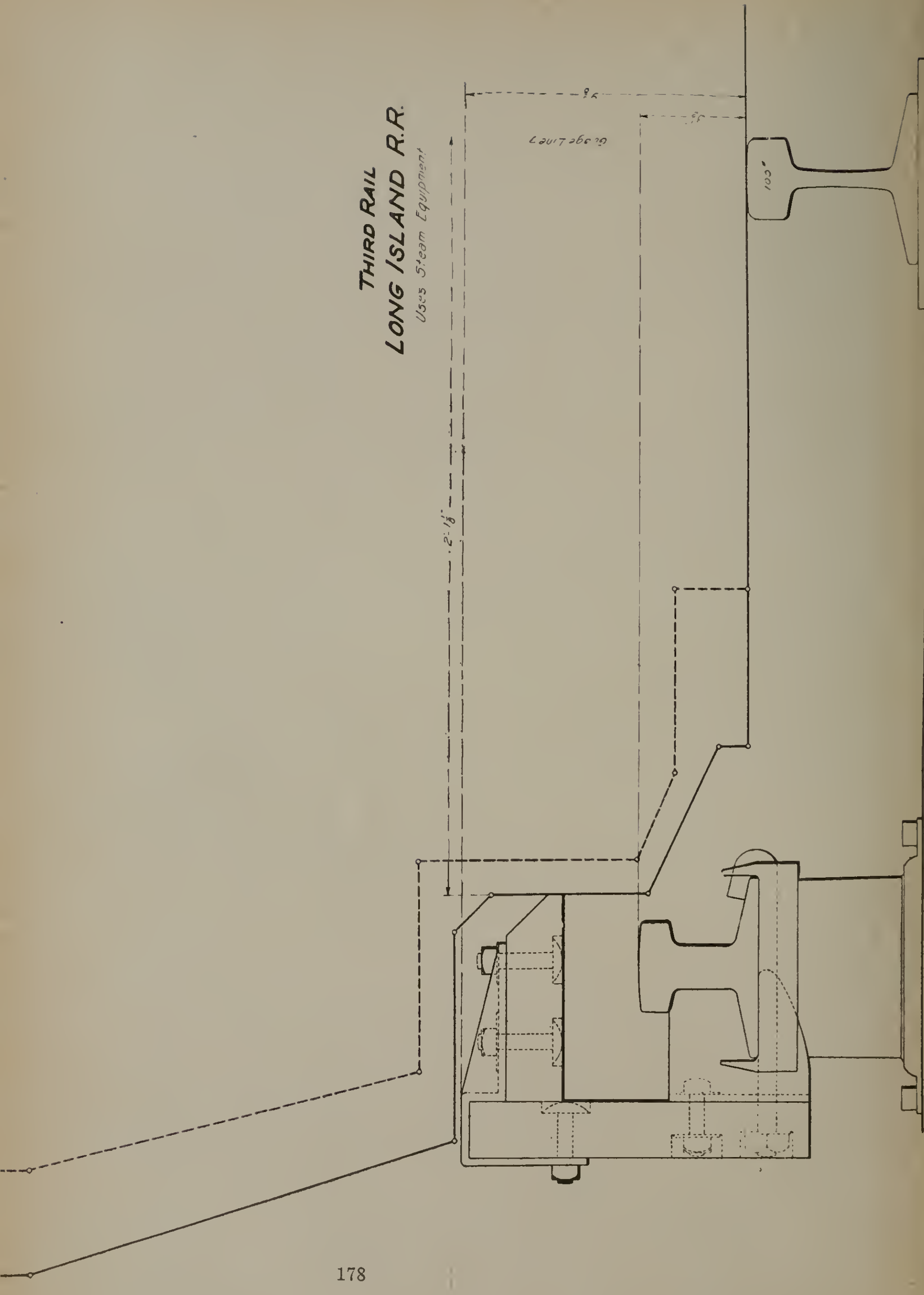

THIRD RAIL
HUDSON & MANHATTAN R.R. CO.
2'-2"
2'-0"
1'-10½"
10"
11½"
4"

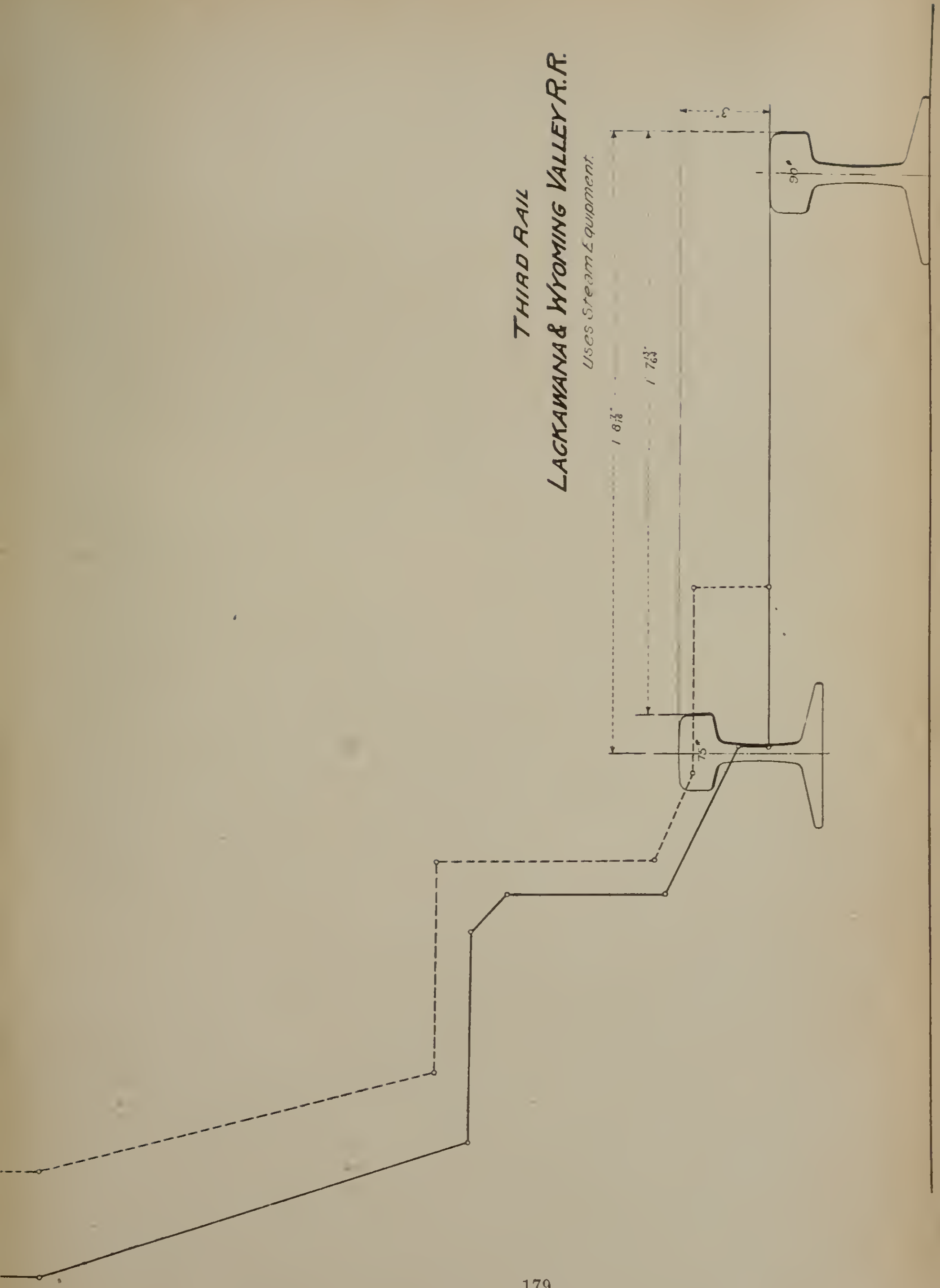

THIRD RAIL
INTERBOROUGH RAPID TRANSIT CO.
2' 2"
1' 10"
4"
75#
100#

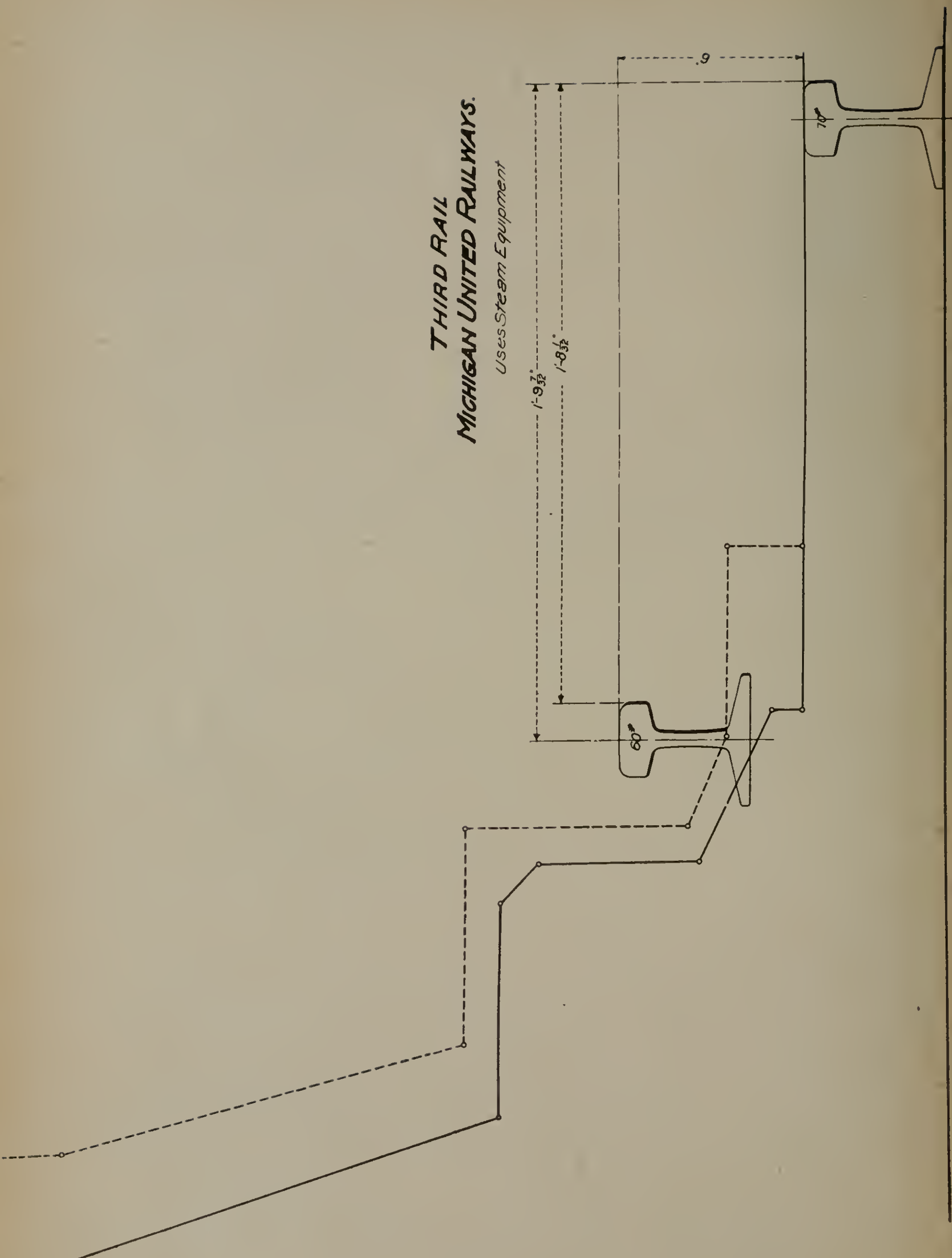

THIRD RAIL
INTERBOROUGH RAPID TRANSIT CO.
WESTCHESTER BRANCH
1' 8¾"
9¾"
7½"
1 5/16"
100#
75#



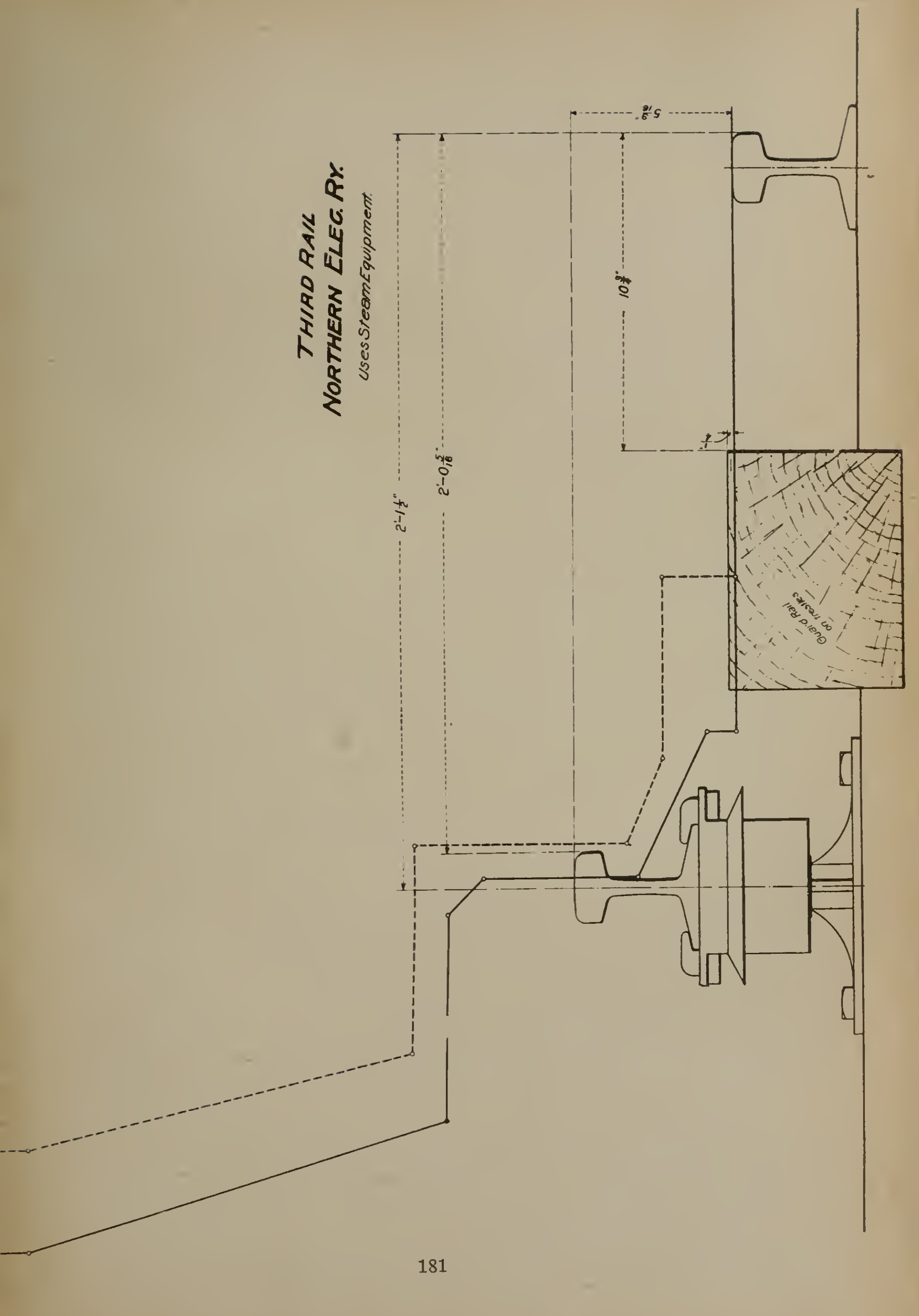
THIRD RAIL
INTERBOROUGH RAPID TRANSIT CO.
ELEVATED DIVISION

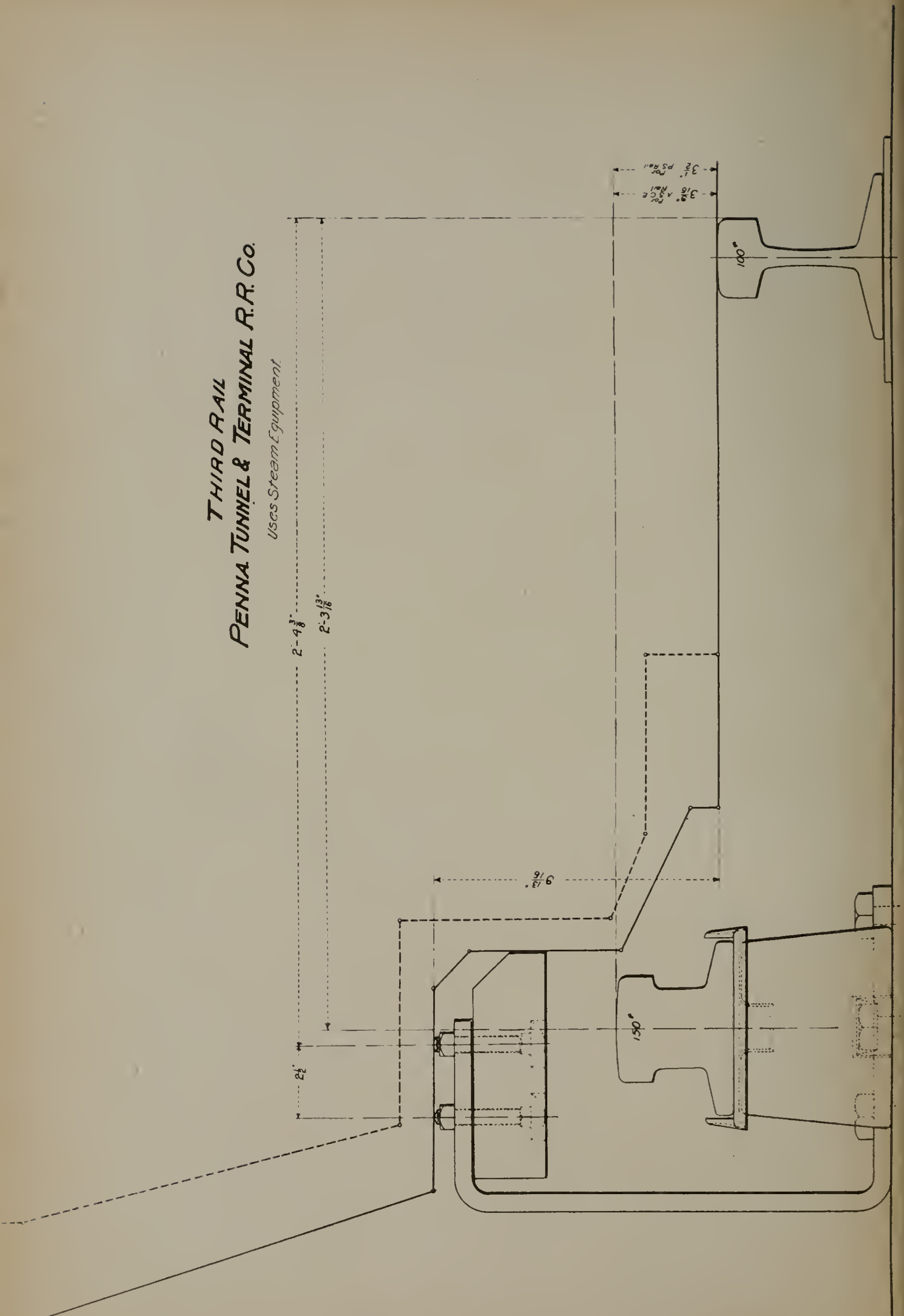

THIRD RAIL
LONG ISLAND R.R.
Uses Steam Equipment
Gage Line

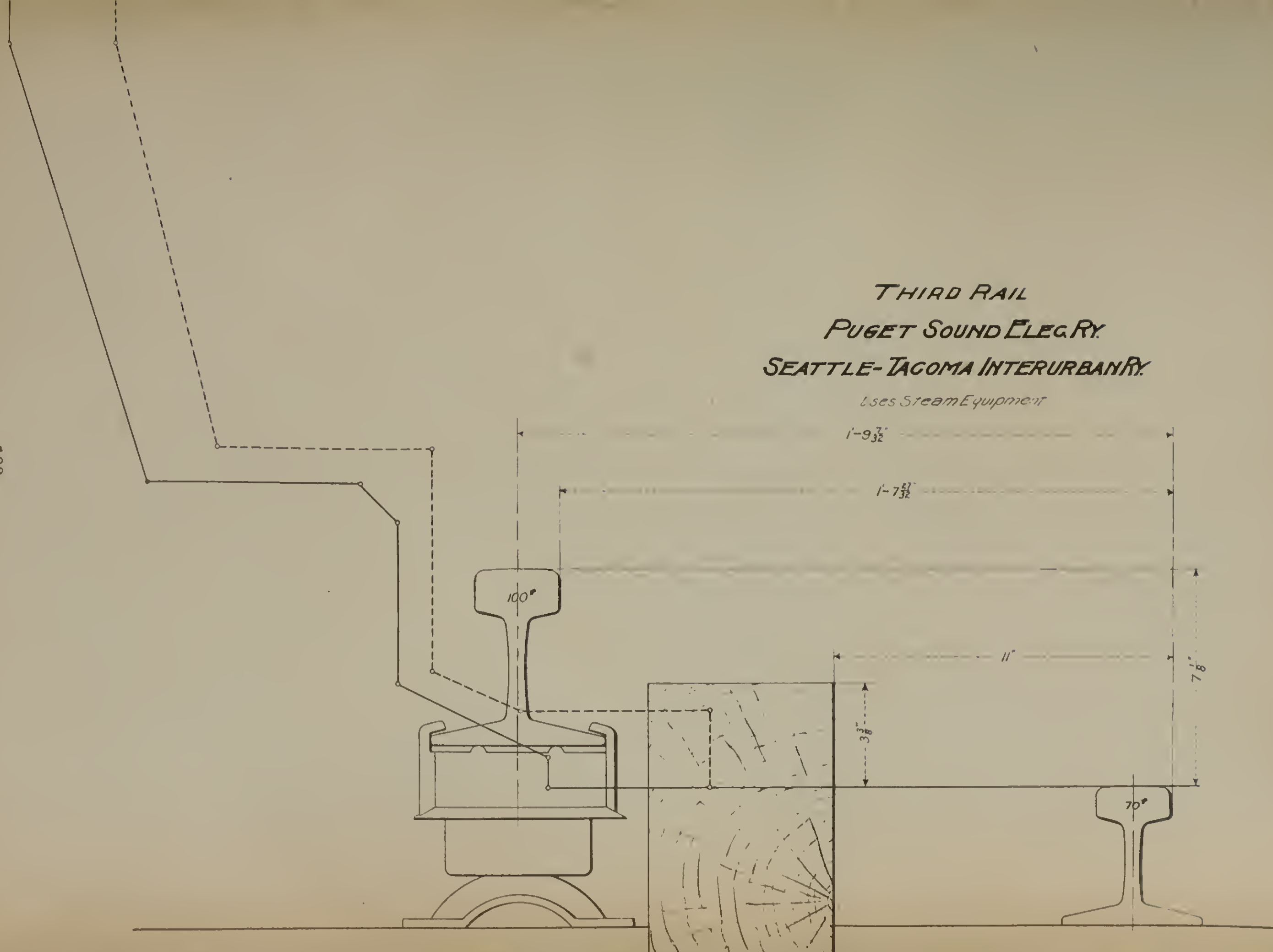

THIRD RAIL
LACKAWANA & WYOMING VALLEY R.R.
Uses Steam Equipment.
3"
1' 8⅞"
1' 7⅞"
90#
75#

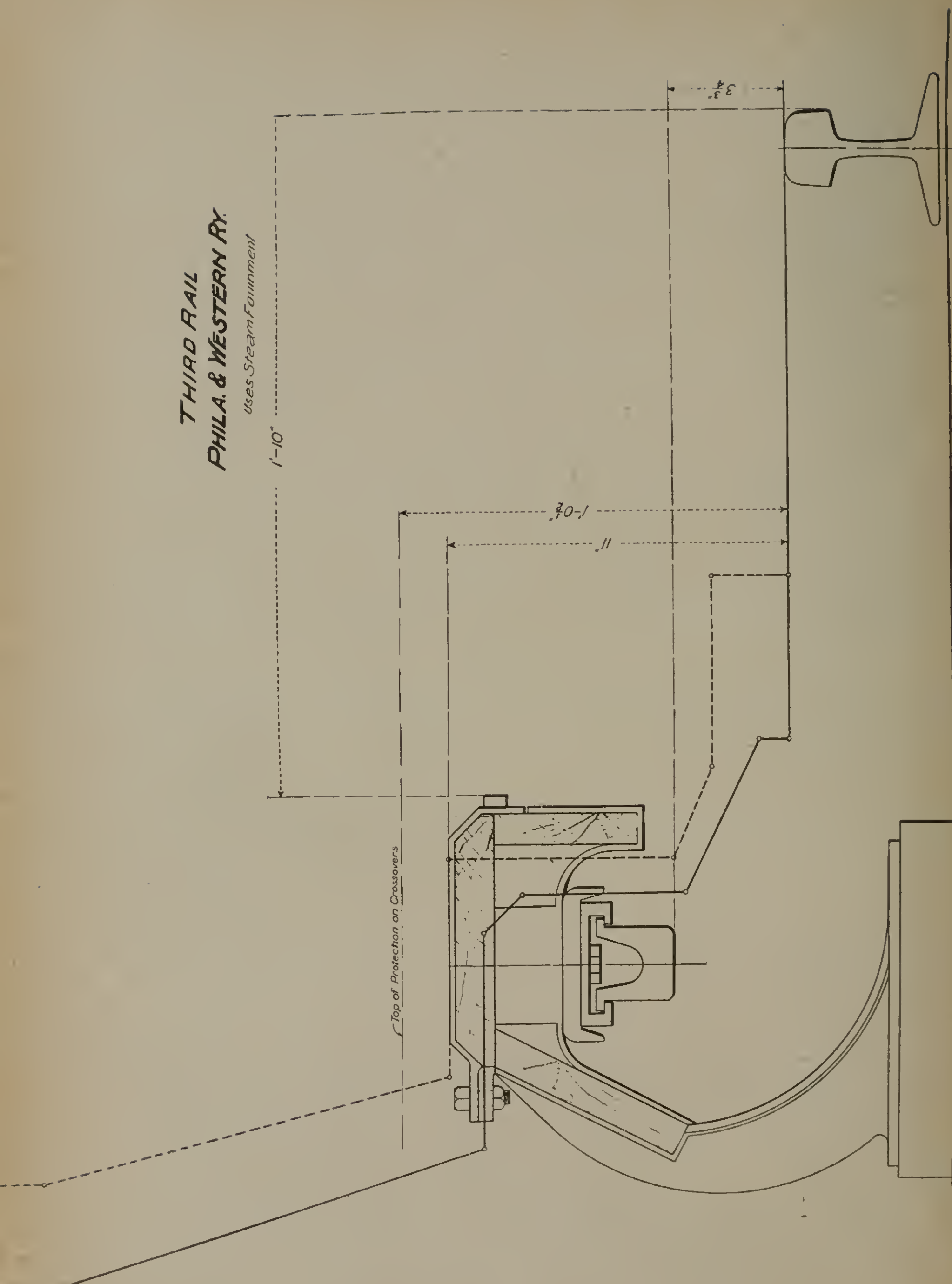


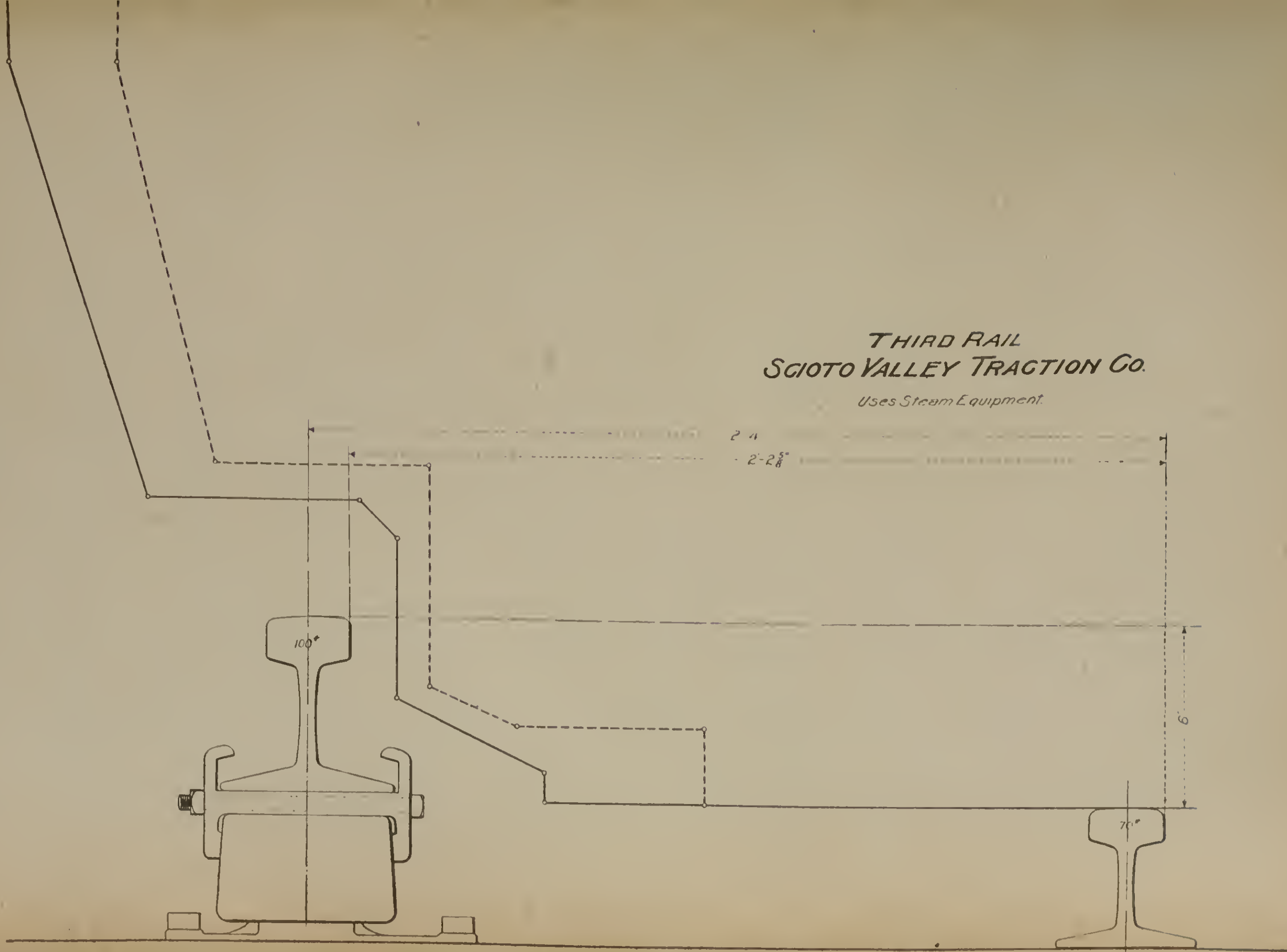
THIRD RAIL
MICHIGAN UNITED RAILWAYS.
Uses Steam Equipment
1'-9 7/32"
1'-8 1/32"
9"
70#
60#


THIRD RAIL
NORTHERN ELEC. RY.
Uses Steam Equipment.
2'-1½"
2'-0 5/16"
10⅜"
5 9/16"
Guard Rail
on trestles

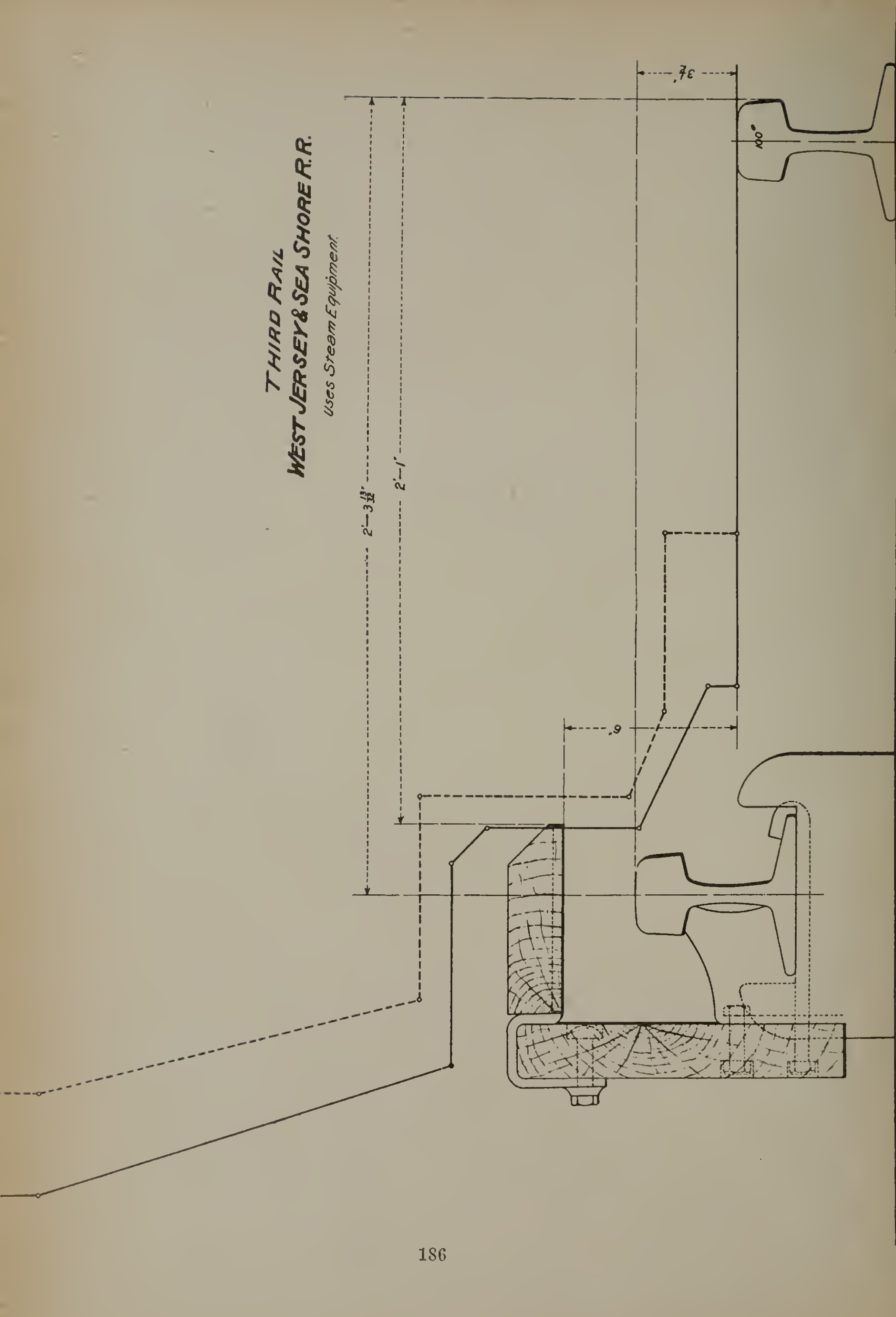

THIRD RAIL
PENNA TUNNEL & TERMINAL R.R. Co.
Uses Steam Equipment
2'-4 3/8"
2'-3 13/16"
2 1/2"
9 13/16"
100#
150#
3 1/2" For PS Rail
3 9/16" For ASCE Rail

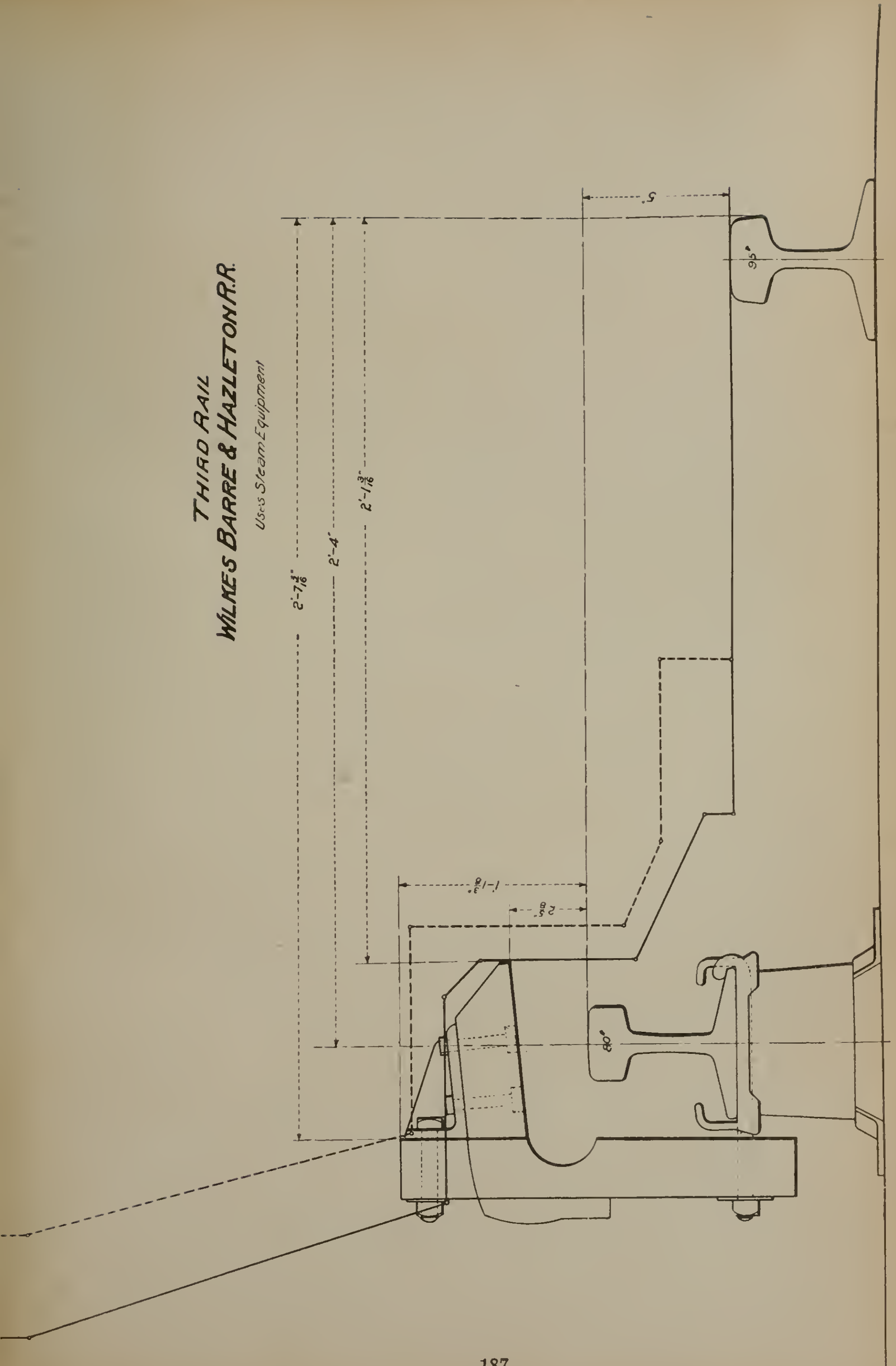

THIRD RAIL
PUGET SOUND ELEC. RY.
SEATTLE-TACOMA INTERURBAN RY.
Uses Steam Equipment
1'-9 7/32"
1'-7 27/32"
11"
7 1/8"
3 3/8"
100#
70#

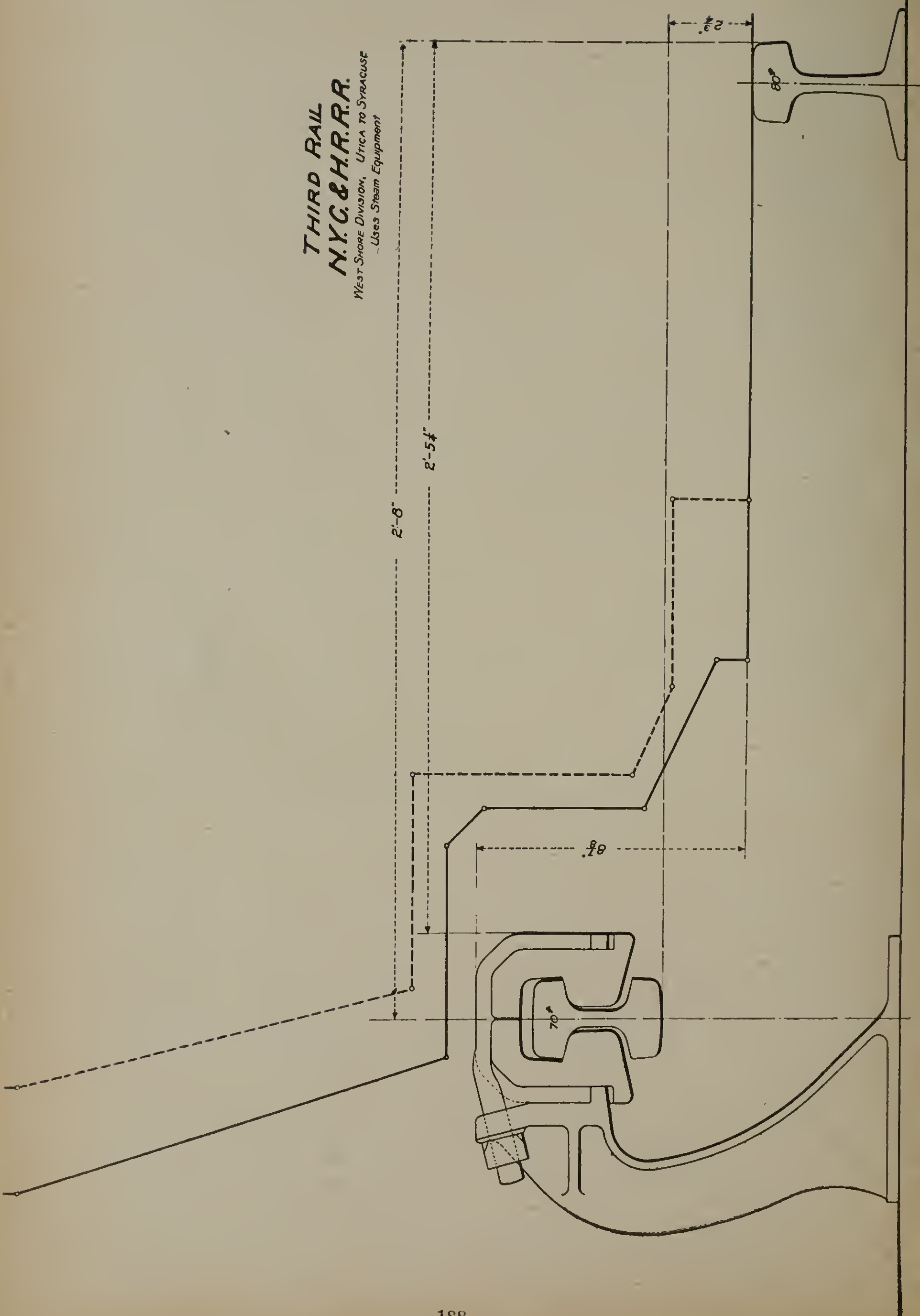

THIRD RAIL
PHILA. & WESTERN RY.
Uses Steam Equipment
1'-10"
1'-0½"
11"
3¾"
Top of Protection on Crossovers

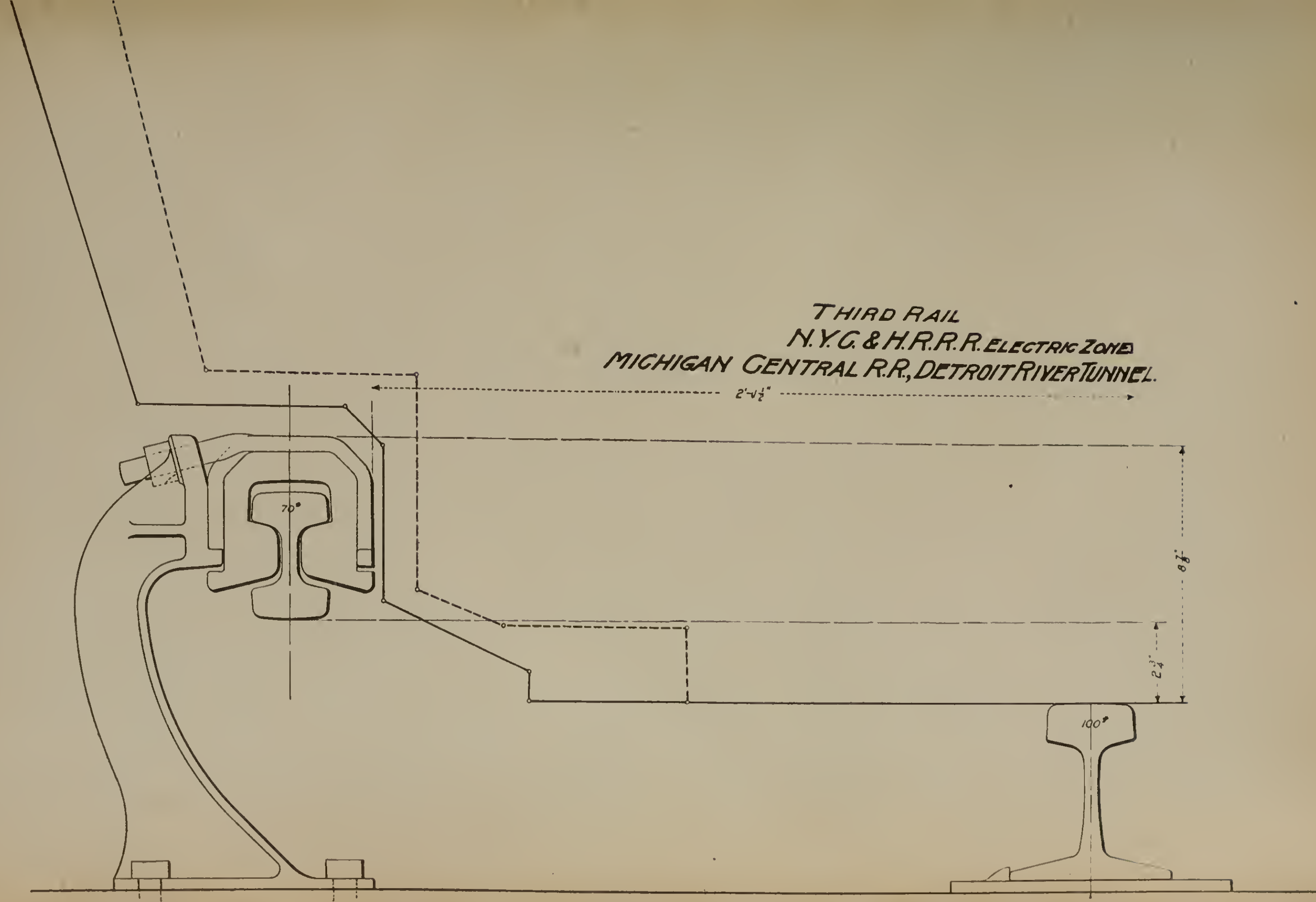


THIRD RAIL
SCIOTO VALLEY TRACTION CO.
Uses Steam Equipment.

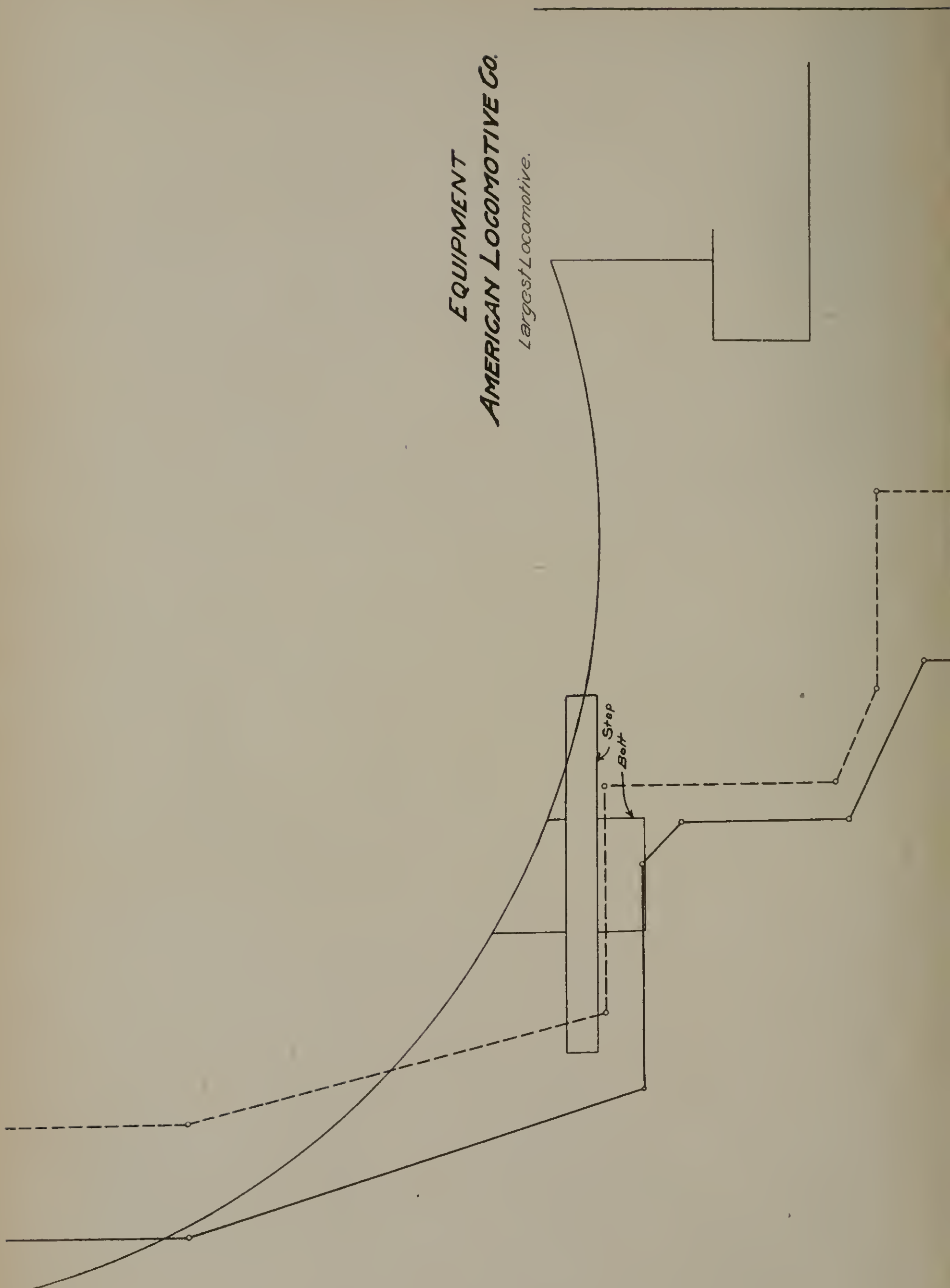

THIRD RAIL
WEST JERSEY & SEA SHORE R.R.
Uses Steam Equipment
2'–1'


THIRD RAIL
WILKES BARRE & HAZLETON R.R.
Uses Steam Equipment
2'-7 1/16"
2'-4"
2'-1 3/16"
5"
95°
80°


THIRD RAIL
N.Y.C.&H.R.R.R.
WEST SHORE DIVISION, UTICA TO SYRACUSE
USES STEAM EQUIPMENT
2'-8"
2'-5¼"
2¾"
8⅞"
80#
70#

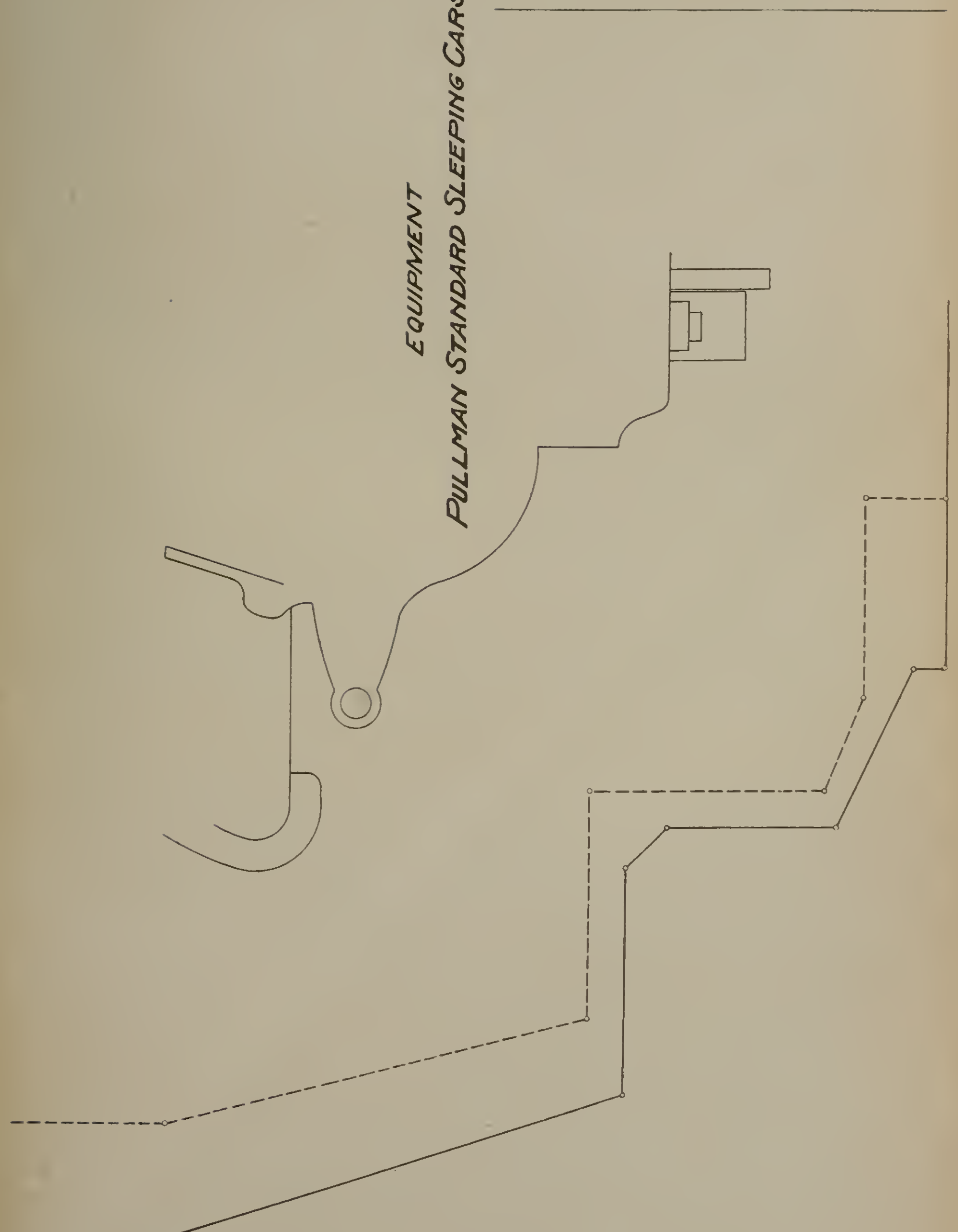


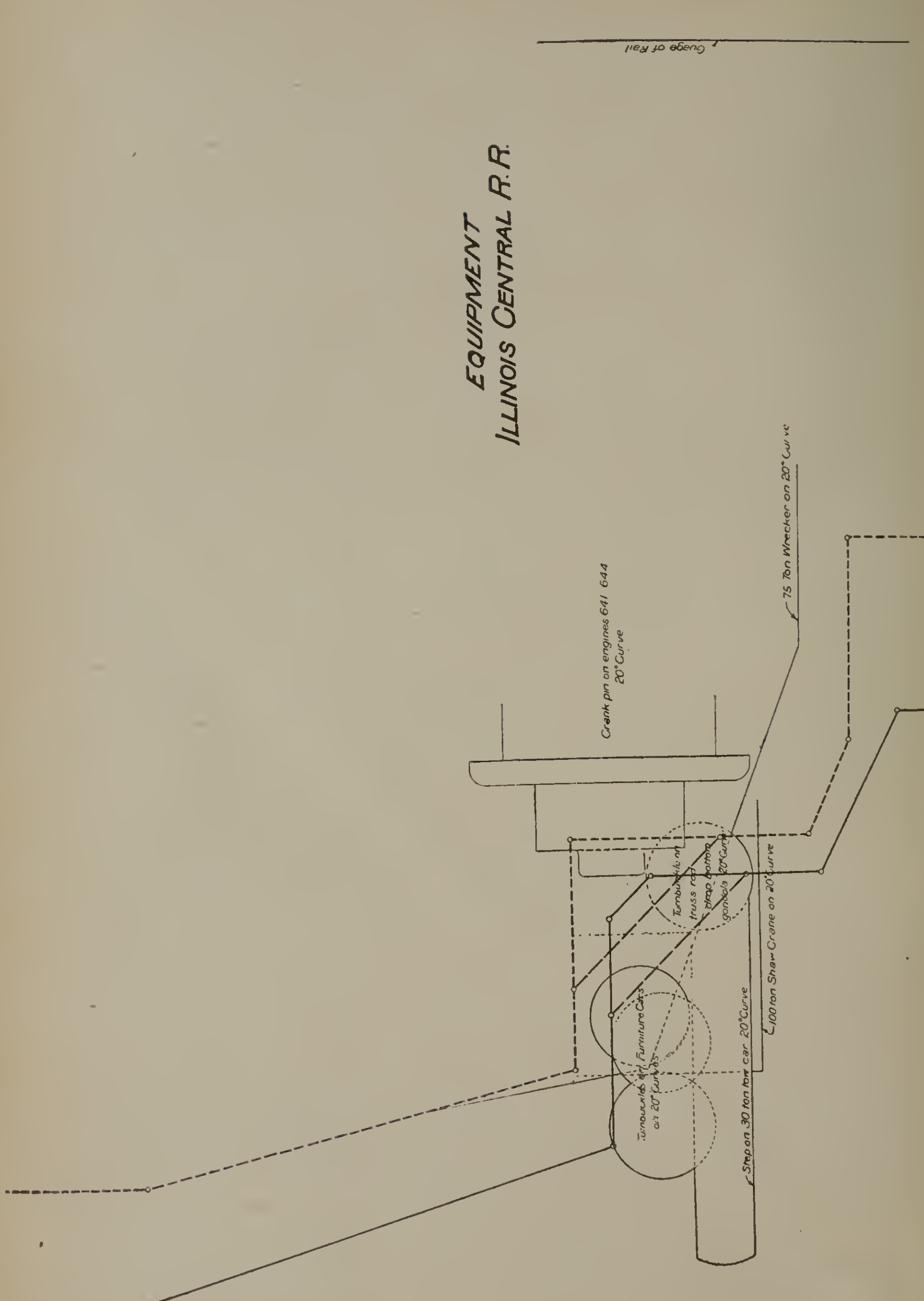
THIRD RAIL
N.Y.C. & H.R.R.R. ELECTRIC ZONE
MICHIGAN CENTRAL R.R., DETROIT RIVER TUNNEL.

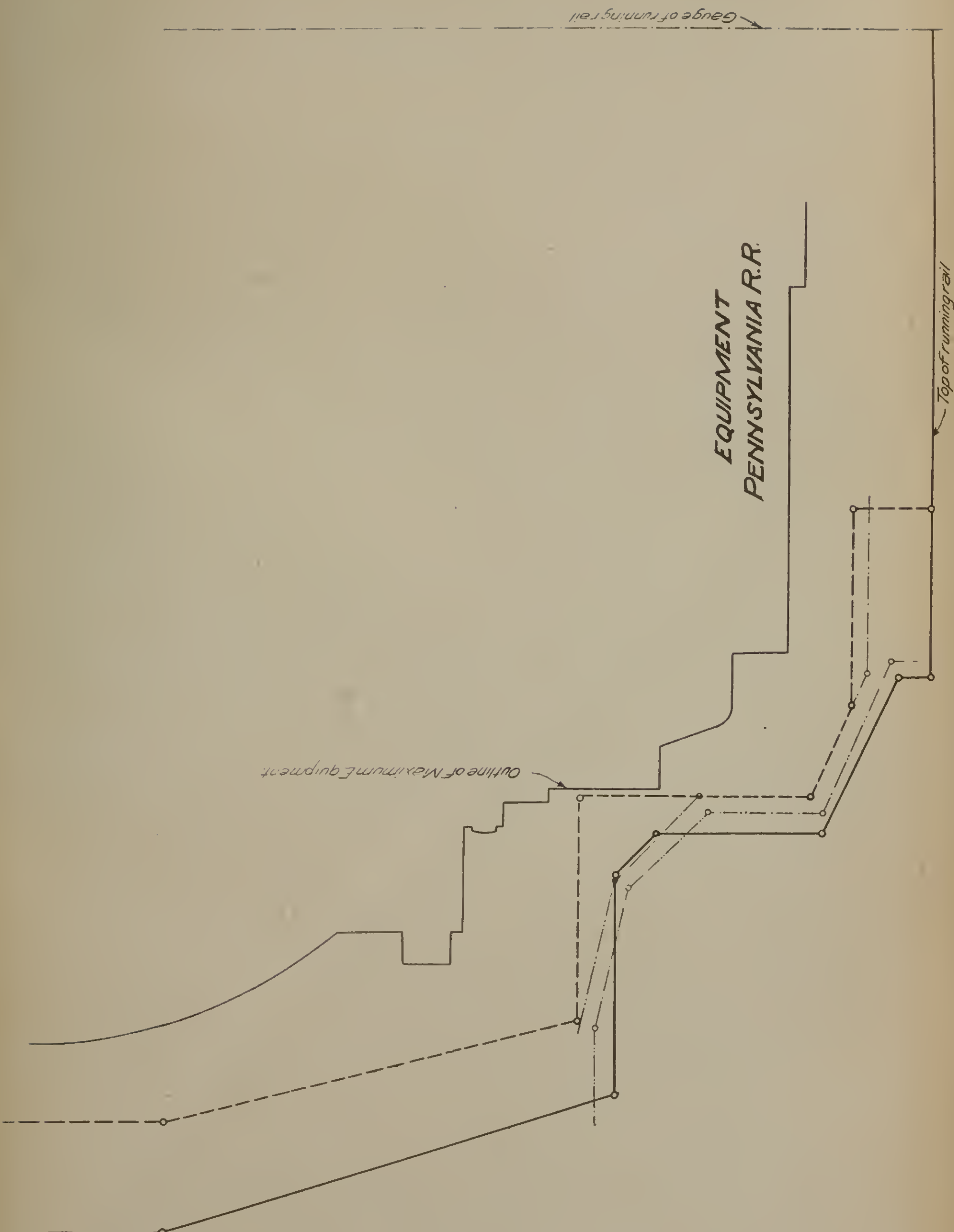

EQUIPMENT
AMERICAN LOCOMOTIVE Co.
Largest Locomotive.
Step
Bolt

EQUIPMENT

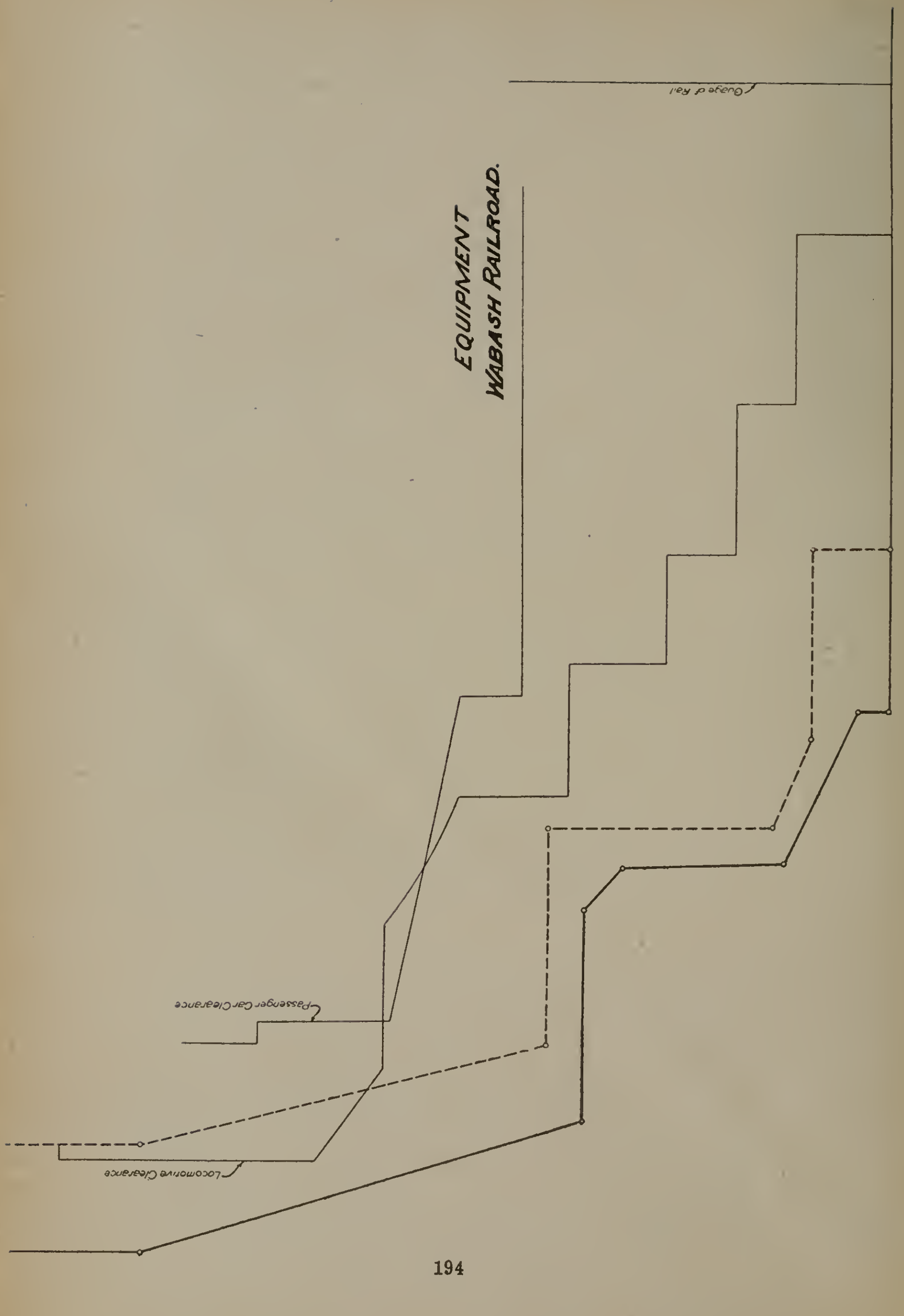
PULLMAN STANDARD SLEEPING CARS.

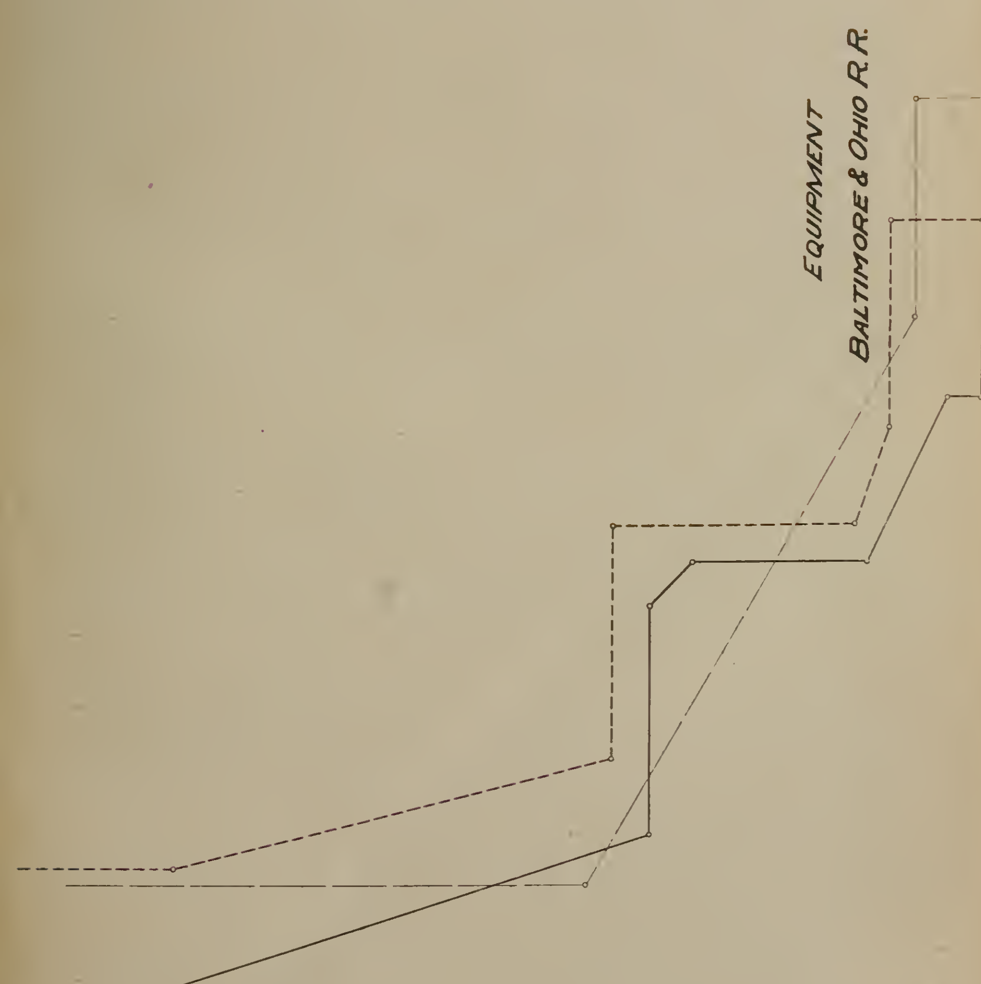


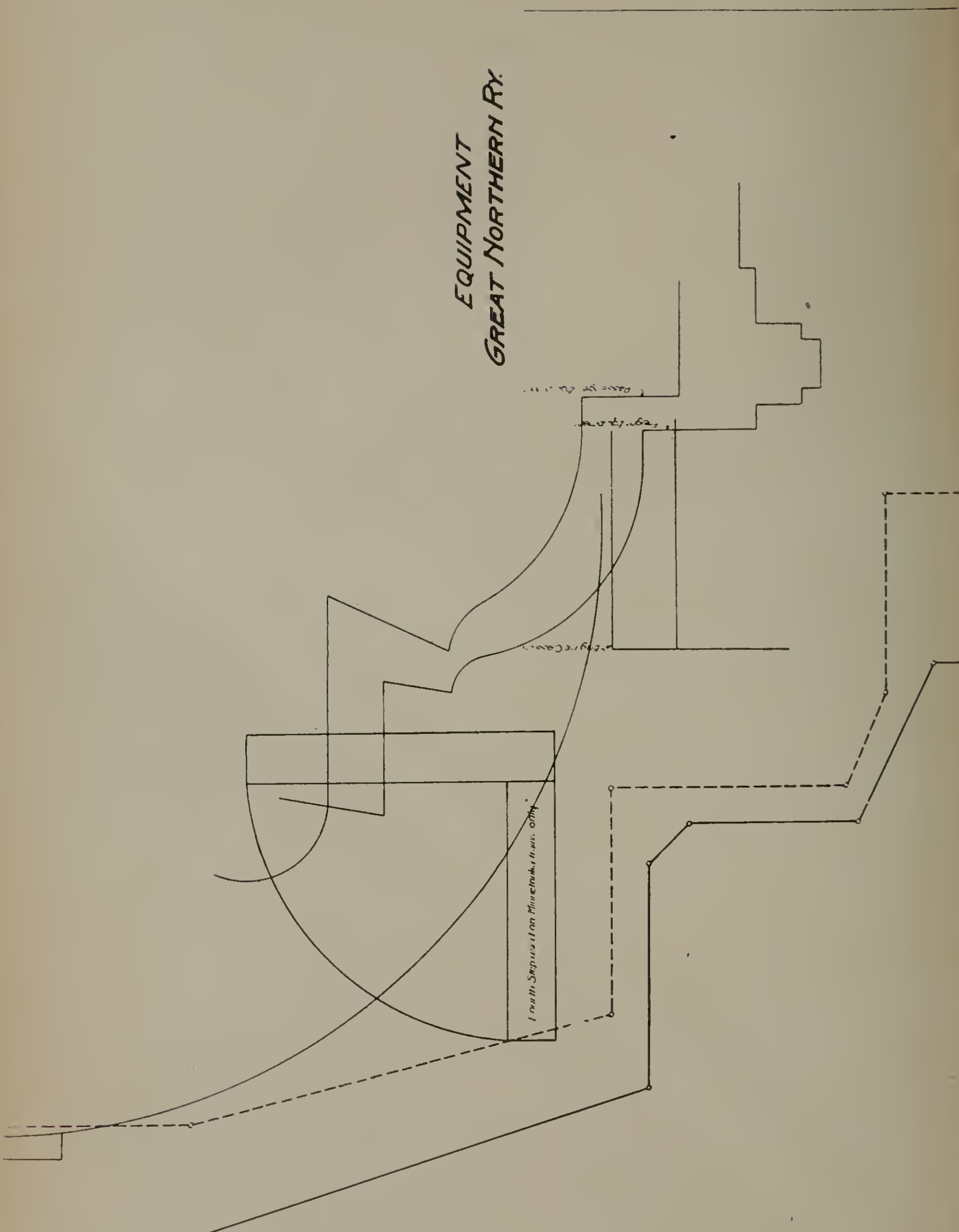

EQUIPMENT
ILLINOIS CENTRAL R.R.
Guage of Rail
75 Ton Wrecker on 20° Curve
Crank pin on engines 641 644
20° Curve
truss rod
gondola 20° Curve
100 ton Shaw Crane on 20° Curve
Step on 30 ton tow car 20° Curve
Furniture Cars
on 20° Curves

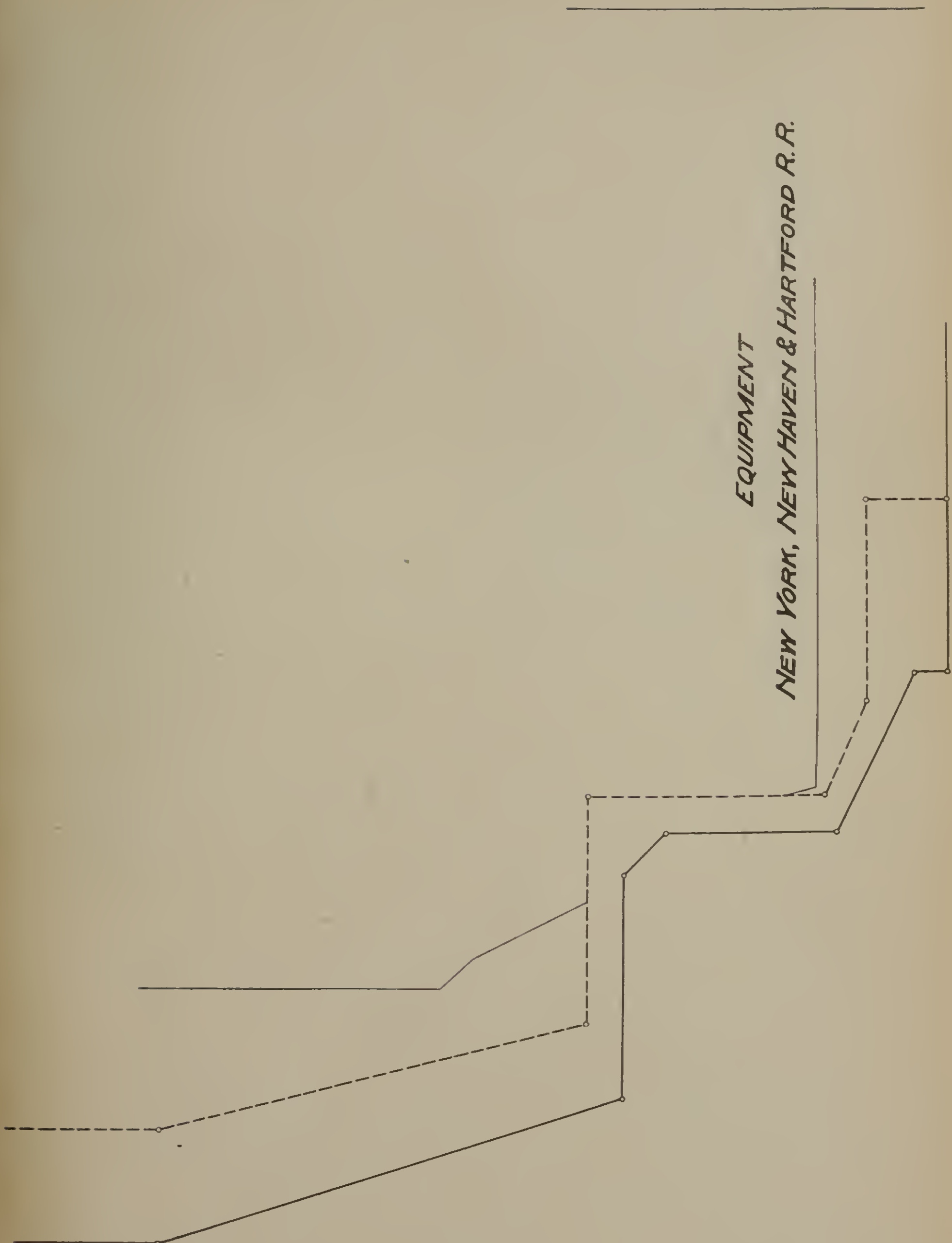


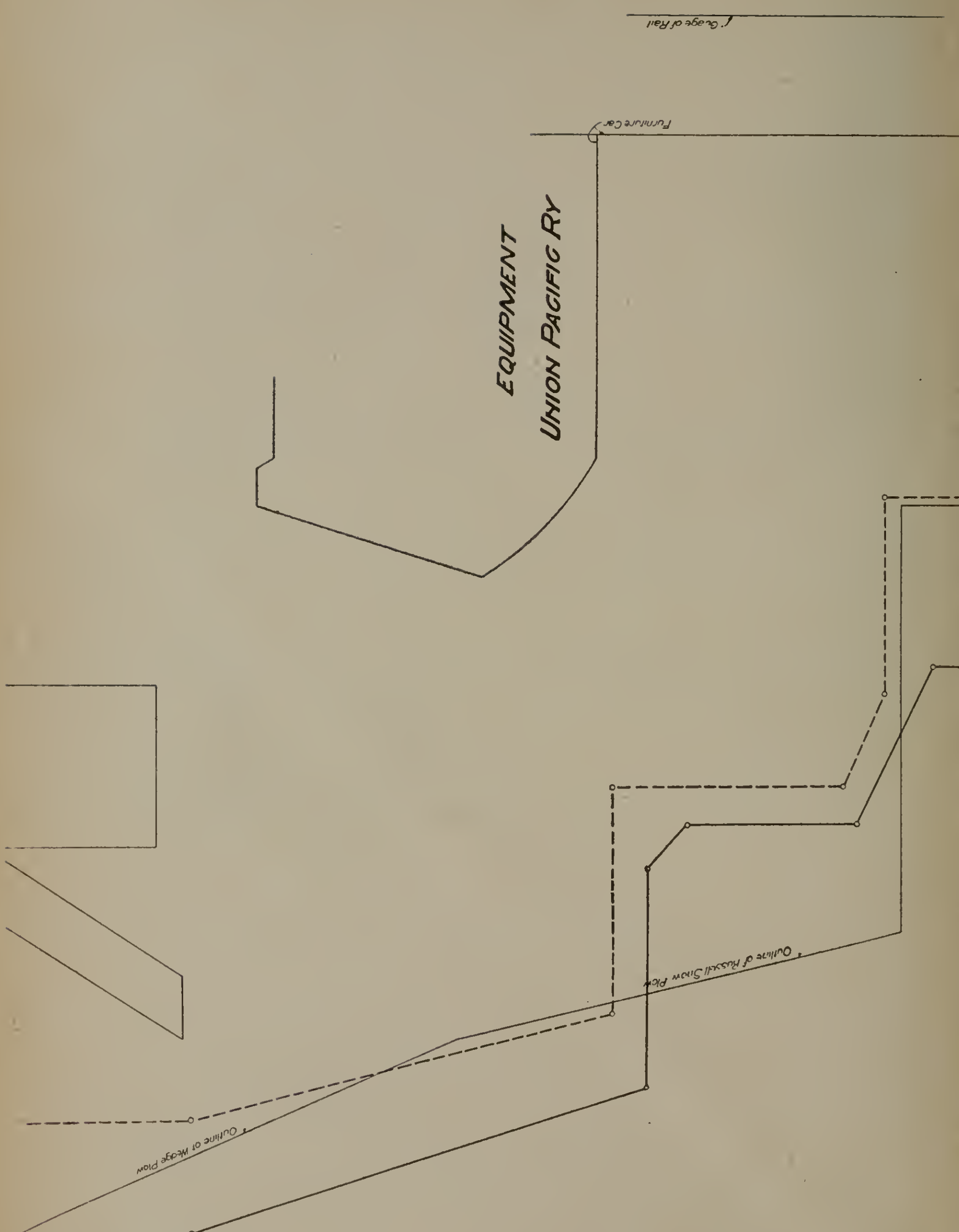
Gauge of running rail
Top of running rail
EQUIPMENT
PENNSYLVANIA R.R.
Outline of Maximum Equipment


EQUIPMENT
WABASH RAILROAD.
Guage of Rail
Passenger Car Clearance
Locomotive Clearance


EQUIPMENT
BALTIMORE & OHIO R.R.


EQUIPMENT
GREAT NORTHERN RY.


EQUIPMENT
NEW YORK, NEW HAVEN & HARTFORD R.R.


EQUIPMENT
UNION PACIFIC RY
Guage of Rail
Furniture Car
Outline of Russell Snow Plow
Outline of Wedge Plow

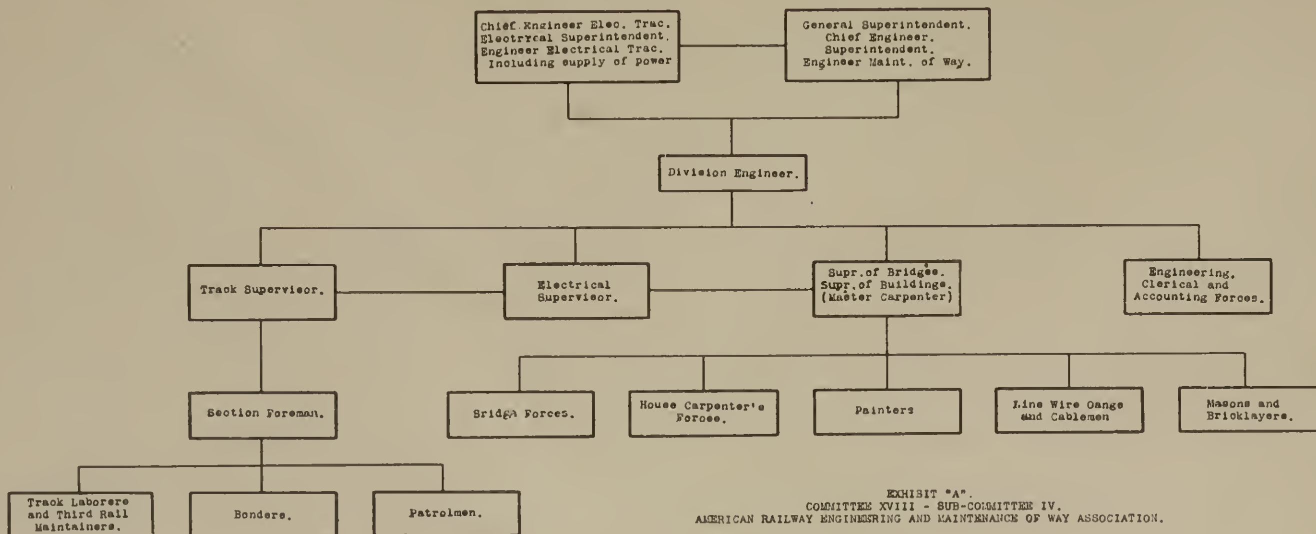


EXHIBIT "A".
COMMITTEE XVIII - SUB-COMMITTEE IV.
AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

Appendix A.

(Bulletin 127.)

TRANSMISSION LINE CROSSINGS.

The following Joint Report of the Committee on Overhead Line Construction of the National Electric Light Association and the Committee on Electricity of the American Railway Engineering and Maintenance of Way Association is respectfully submitted:

The increase in the number of high-tension transmission lines and the development in the protective regulations enforced by public service corporations and municipal authorities have created a demand for special methods of construction. Public service corporations in general, and the railways in particular, are yearly incurring greater expense in the attempt to avoid interruptions to service or danger to employés or to the public.

The attention now given to the subject is due, in large part, to the presence of occasional lines of relatively high voltage. Such lines are more objectionable neighbors, and contact with them is unquestionably dangerous, but the greater percentage of accidents is chargeable to the more numerous low-voltage lines.

Any voltage over 250 volts, with the currents generally used, may cause painful, and under exceptional conditions, fatal injury. The danger from fire is not confined to any particular voltage, and while an interruption to the service of foreign lines may be guarded against by protective devices, such protection is merely electrical and of no avail against mechanical injury.

It is, therefore, necessary to consider all phases of the question, as well as all voltages, but since the probability of danger to life or property is mainly confined to the immediate vicinity of the power line, and particularly to the space over or under the same, this report will deal with the so-called "Crossings," and not with the construction of the power line *per se*. The crossings of trolley contact wires will not be included, because the conditions governing their construction are radically different and the protective measures possible for transmission lines could not be enforced.

Before discussing either the responsibility of the transmission company, or the measures calculated to insure a greater degree of safety, the following "Accidents" should be noted, although, for any given crossing, some of them would be impossible and others extremely improbable:

(1) Injury or death from direct contact with a live wire.

(2) Injury or death from indirect contact, i. e., contact with an object, harmless in itself, but which is in contact with a live wire.

(3) Fires, caused by either direct or indirect contact.

(4) Interference with the operation of signals, and, therefore, with the safe and convenient movement of trains.

(5) Interruption or interference with the service of telegraph and telephone lines, not included in the above classes.

(6) Electrical interference with the proper operation of other power circuits.

(7) Mechanical obstruction of tracks by large cables.

Accidents of the first class vary greatly, and the amount of injury depends as much upon the particular circumstances as upon the voltage present. It must be generally admitted, however, that there is danger in any direct contact above certain voltages, and that prevention is desirable.

Direct contact is usually due to a fallen wire, but not necessarily so, since the slackening or pulling through of the sag of the power wire may lower it sufficiently to permit contact with those riding on the tops of freight cars or other vehicles. Power lines immediately adjacent to buildings, bridges, or other accessible elevations, are more or less subject to direct contact, through the medium of wires or other objects, either carelessly or maliciously thrown across the power wires.

While no sympathy need be wasted upon wire thieves, it is more than possible that the small boy, the usual "innocent" trespasser, may bring himself in contact with power circuits by climbing the poles. It is impossible to guard absolutely against this last contingency, but it is to be expected that the enforcement of laws affecting trespassers will, in time, produce the desired result.

The most common example of indirect contact is probably that of telegraph or telephone wires falling across or otherwise brought in contact with a power line, and the consequent injury of persons who may be at a considerable distance from the point of contact.

In a similar manner fires may be started, either by the direct contact of the original live wire, or by other circuits with which it comes in contact.

A metallic connection with the running rails, on roads equipped with electrically controlled signals, serves to interrupt the operation of the signals and would seriously interfere with the safe and regular running of trains. The result would very likely be to cause signals to fail in the "clear" position, a condition extremely dangerous to train operation. In addition, should the voltage in contact with the signal apparatus, or its connections, exceed a certain amount, the signal equipment would be materially injured.

Interference with the service of telegraph, telephone, or other power lines may be caused by inductive currents, if the lines are parallel, although the subject is still open to considerable investigation. In general, the greater the distance between the two lines the less the disturbance. In existing installations, where local conditions precluded the absolute separation of the lines, transposition of the wires, together with other corrective measures, has been reasonably satisfactory in result.

Having outlined the general types of "Accident," the *possible* causes of accident may be stated as follows:

(1) *Injury to the poles, arms, pins or insulators,* by

(a) Windstorms, particularly in conjunction with snow or sleet.

(b) Unusual loads imposed upon the structure by falling trees, buildings, etc., either by direct impact or through excessive tension in the wires.

(c) Derailed railroad or trolley cars or the collision of heavy vehicles.

(d) Fire, from burning brush, the ignition of a pole or arms in case of fire in an adjoining building, or the collapse of the pole line at the crossing, due to failure from fire in another span.

(e) Decay or corrosion.

(f) Lightning.

(g) Arcs from the power wires.

(h) Insufficient foundation, due to errors in design or workmanship, or to subsequent natural causes.

(i) Increased tension in the wires, on curves, due to improper stringing, and introducing excessive stresses in the poles.

(j) Malicious mischief.

(2) *Failure of the span wire,* by

(a) Excessive ice and wind loads, causing the wires to break or to slack down.

(b) Unusual loads, due to falling trees, buildings, etc.

(c) Melting, or partial burning, of the wires, by adjoining fires.

(d) Burning of the wires by arcs, due to defective, dirty, or broken insulators.

(e) Lightning.

(f) Arcs, due to foreign objects in contact with the wires

(g) Arcs, due to the power wires swinging into contact.

(h) Weak spots, due to initial faults or careless handling.

(i) Weak joints in the wire.

(j) Mechanical injury, by linemen placing tie wires, clamps, etc. more particularly as applied to solid, hard-drawn wire.

(k) Broken tie wires, or other attachments, allowing the power wires to fall from the structure or to fall upon a cross-arm and burn either the arm or the wire.

(l) Corrosion.

(m) Excessive heating by heavy currents, with a consequent reduction in the tensile strength of the wires.

The above list embraces practically all the possible causes of accident, and they have been enumerated, in order to more definitely outline the desirable features of good construction. It is hardly possible that any one crossing would be subject to all the above causes of accident, and in justice to existing construction it may be admitted that the number of accidents per mile of line is extremely small.

However, the interests of the power company, and of the foreign company, are nearly identical, since each is desirous of avoiding accidents, and the real issue is the cost of protection versus the degree of safety assured.

Nearly all of the foregoing causes of accident may be very successfully guarded against, in the design, workmanship, and maintenance, and by providing the necessary clearance between the power line and adjoining tracks, buildings, trees, etc.

The remainder, i. e., (1-f), (1-g), (2-d) and (2-e), are due to lightning and arcing, and while not usually preventable, may be made less effective by precautionary measures.

The initial expense, which is warranted in any given installation, depends upon the character of the power line, and more than one class of construction may be desirable.

Several suggestions have been made as to the proper divisions, and discussion of this feature is especially requested. Merely as suggestions the following are given for consideration:

CLASSES OF CONSTRUCTION.

(*A*) *By Voltage and Circuit:*

(1) All constant potential circuits up to and including 6,600 volts and all constant-current circuits not exceeding 10,000 volts.

(2) 6,600 to 24,000 volts. A. C.

(3) 24,000 to 44,000 volts. A. C.

(4) Over 44,000 volts. A. C.

(*B*) *By Voltage:*

(1) 220 to 5,000 volts.

(2) 5,000 volts and over.

Attention is called to the fact that voltage may not be the governing feature, as amperage, in some cases, is more important.

SPECIFICATIONS.

INTRODUCTORY DISCUSSION.

Conditions of Loading:

*The function of a pole is that of a cantilever beam rather than a column. The external forces are due to dead, ice, and wind loads, which, with the exception of the pressure on the pole surface, must be transmitted to the pole by the wires.

The weight of the wires and their coating of sleet, together with any vertical component of the wind pressure, the weight of cross-arms, insulators and the pole itself, is a vertical load, which the pole carries as a column. The pressure of the wind on the wires, whose diameter is increased by the sleet, and upon the pole structure, is assumed as acting in the most unfavorable direction and at a right angle with the line. The above vertical and horizontal forces act together upon the pole, but since the horizontal forces are applied at the wires, and, therefore, near the top of the pole, their effect is much greater than the effect of the vertical forces.

In the case of a pole placed at a bend in the line there must be added to the foregoing the horizontal component of the tension in the wires, i. e., twice the maximum tension multiplied by the sine of one-half the angle of the bend. (Fig. 1.)

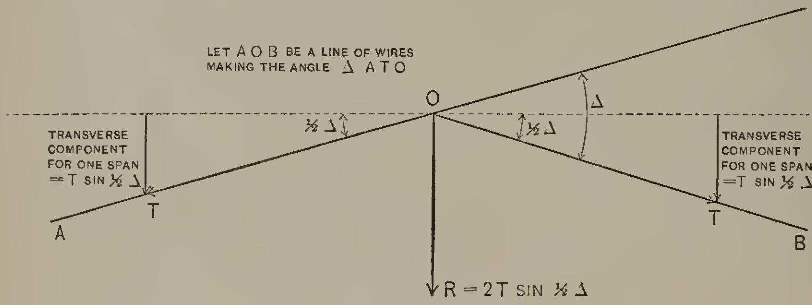


FIG. 1.

Again, in case the sags in adjoining spans are not so adjusted as to balance the tension of the wires either side of the pole, there will be an unbalanced pull in the direction of the line, which must be considered in conjunction with the vertical and horizontal forces first mentioned. Unbalanced tension may also be produced by unequal ice and wind loads in adjoining spans.

If it is further assumed that all, or part, of the wires may be broken by excessive loading, faulty material, or by burning, then the pole must withstand a longitudinal force equal to the tension in the wires in the unbroken span.

*"Reinforced Concrete Poles," by R. D. Coombs and C. L. Slocum.

On the other hand, it can be shown by a rather complicated mathematical demonstration that, owing to certain properties of the catenary curve, a slight bending in a number of poles will balance the tensions in adjoining spans.

This is due to the fact that the tension in a wire hanging in a catenary curve or as hereafter assumed for convenience in calculation, in a parabola, is greatly decreased if the span length is shortened while the length of wire per span remains unchanged. Vice versa, increasing the span length while the length of wire per span remains unchanged increases the tension.

If it is assumed that all the wires in one span are broken, then the first pole is subject to the unbalanced tension of all the wires in the unbroken span and bends away from the break. This shortens the next span length, decreases the tension in that span, and allows the second pole to be bent away from the break. Successive bending occurs, in decreasing amounts, until a point of equilibrium is reached at which the wire tension next to the break is considerably less than the original tension.

If it is assumed that less than the entire number of wires are broken, then the bending of the first pole increases the span length of the remaining wires and by increasing their tension causes them to exert a greater pull toward the break and thus decreases the unbalanced pull upon the pole.

However, the usual attachments for fastening line wires to the insulators do not have sufficient strength to develop the strength of the wire and, therefore, a broken wire would pull through into the adjoining spans before exerting its maximum tension upon the poles. For this reason, and because equilibrium by bending may result in over-stressing the poles, wires, pins or insulators, it is not usually possible to take advantage of this method of design.

In assuming the possibility of broken wires, it becomes necessary to assume which wires may break, as well as their number. If the wires furthest from the pole are broken, the effect upon the crossarms is much greater than in the case of wires near the pole. If all the broken wires are on one side of the pole, the torsional effect upon the pole must be considered.

Since the probability of wire failure, from external loading, or from faulty material, may be governed by the allowable unit stresses and careful inspection, the breaking of wires may be said to depend upon their burning.

The probability of burning depends upon the voltage, amperage, insulation, and the character of the attachment to the pole. If the attachment, or clamping device, is such that an auxiliary connection is brought into action when the power wire fails, the burning of the wire will not effect the loading on the pole. If the line voltage is such that arcs may be formed, enveloping a part, or all, of the pole top, it is possible that adjoining wires may be burned beyond the clamps.

It would, therefore, appear that the number of broken wires to be assumed should depend upon the total number and spacing of the wires, the voltage, the amperage, and the clamping device.

Ice and Wind Loads:

*Omitting from consideration the effects of tornadoes and cyclones, it is necessary to determine, or assume, the maximum velocity of the wind, for general practice, or for any particular locality. . . . The records of the United States Weather Bureau—omitting tornadoes, cyclones and violent gales, occurring in some particularly exposed situations—give a maximum indicated velocity of 100 miles per hour. . . . Table No. 1 shows the maximum velocities observed at a number of stations by the United States Weather Bureau.

TABLE NO. I.

Observatory.	Period.	Max. Vel. Indicated.
Chicago, Ill.	1871-1906	90
Buffalo, N. Y.	1871-1907	90
Galveston, Texas	1894-1903	84
New York, N. Y.	1871-1907	80
Eastport, Maine	1873-1907	78
Observatory.	Period.	Max. Vel. Indicated.
Savannah, Ga.	1894-1903	76
Philadelphia, Pa.	1872-1907	75
Bismarck, N. D.	1894-1903	72
Boston, Mass.	1873-1907	72
Salt Lake City, Utah	1894-1903	60

A tabulation, by months, of the highest indicated velocities recorded by the United States Weather Bureau at the New York City station from 1884 to 1906, and of the number of different twelve-hour periods, during which a maximum velocity of sixty miles or more was observed from 1895 to 1906, shows that:

The maximum velocity of 80 miles per hour occurred during a sleet storm.

The maximum velocities occur during the winter months when sleet may be on the wires.

Indicated velocities of more than 80 miles per hour will rarely, if ever, occur during the life of a given structure.

Indicated velocities of from 65 to 75 miles per hour may be expected several times each year, though much less frequently in conjunction with sleet.

In Table No. 2 are given the equivalent "Actual" velocities corresponding to those "Indicated" by anemometer readings, and the pressures per square foot produced on flat and cylindrical surfaces.

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*"Overhead Construction for High-Tension Electric Traction or Transmission," by R. D. Coombs, Trans. Am. Soc. C. E., Vol. LX.

TABLE NO. 2.—WIND PRESSURES AND VELOCITIES.

Ind. Vel. M. P. H.	Actual Vel. M. P. H.	Press. Per Sq. Ft. on Cylinders $P = .0025\ V^2$	Press. Per Sq. Ft. on Flat Surfaces $P = .0042\ V^2$.
30.	25.7	1.7	2.8
40.	33.3	2.8	4.6
50.	40.8	4.2	7.0
60.	48.0	5.8	9.7
70.	55.2	7.6	12.8
80.	62.2	9.7	16.2
90.	69.2	12.0	20.1
100.	76.2	14.6	23.3
110.	83.2	17.3	29.1
120.	90.2	20.3	34.2

$P =$ Pressure in lbs. per sq. ft.
$V =$ Velocity (actual) in miles per hour.

Experience in sleet storms indicates that generally throughout this country a deposit of ice of about one-half inch thickness may be expected at irregular intervals. Greater thicknesses are sometimes encountered, but the heavier deposits are usually snow-ice of lighter weight and with less adhesion to the wires. It may reasonably be expected that a portion, at least, of these larger accretions will be broken off by the rising wind, so that the final average load on a span will be approximately equivalent to a uniform thickness of one-half inch of clear ice.

To a certain extent the thickness of ice is independent of the diameter of the wire, though it has sometimes been assumed that a thickness equal to the diameter would occur. This is manifestly wrong for the smaller sizes of wire, as is proven by the coating of twigs in every sleet storm and by actual experience with line wires.

Inasmuch as the ice and wind loads are both acting under maximum loading, some reasonable combination must be assumed. Since the surface exposed to wind pressure is the diameter of the ice-covered wire, if no ice load is present, it would be necessary to assume an extremely high wind velocity to obtain a maximum load equivalent to a moderate combined load.

In Appendix B are given the loads per linear foot of wire, for various sizes of wire and conditions of loading.

Cradles:

The function of a cradle, net or guard wire, is to prevent contact with a falling power wire, or with a telegraph, telephone or other wire, falling on the power wire.

Inasmuch as prevention is more desirable than cure, the latest practice in this country is, as nearly as may be possible, to so install the power line that the line wires will not fall. In other words, the sums heretofore spent on cradle may more profitably be expended in improving the primary installation.

Cradles, to be effective, require a considerable mass of material which, if supported by the power-line poles, introduces a greater burden upon them than that of the power wires. A properly designed cradle should almost enclose the power line, since there is no justification for assuming that a wire will fall vertically and within the confines of a flat net of restricted width. When wires fail under tension, the ends often whip out laterally or curl in a spiral from the effects of the original reeling. To prevent burning by the power wire and to provide an efficient ground, in case the cradle is of the grounded variety, the members of the cradle must have a mass dependent upon the current on the power line.

The second type of cradle mentioned, i. e., that enclosing the telegraph or telephone line, is somewhat less objectionable, since it can be made a more effective physical shield, is located upon a lower line, and does not introduce loads upon the power poles. This form of cradle may sometimes be placed under a telegraph or telephone line to prevent the wires of that line from falling upon power wires beneath them, although the location of a telephone or telegraph line above a power line is very undesirable and to be avoided if possible.

The general use of cradles would involve the presence of many unsightly structures over public thoroughfares and railroad rights-of-way, particularly if the types used in Europe, where the cradle has attained its greatest development, are to be followed.

Grounding:

In order to prevent the burning of wooden pins and crossarms by arcs from defective insulators or fallen wires, by causing the circuit breakers to act, some specifications have required that crossarms should be of metal, or be provided with metallic strips, and that they should be grounded. In other instances, metal grounding arms have been placed below the wires so that a falling wire would come in contact with them.

It has also been required that the poles themselves should be grounded, particularly in the case of metal poles.

On the other hand, the grounding of wooden crossarms results in the loss of the insulating value of the wooden arm. In dry weather a wire falling upon a wooden arm would not necessarily burn either the arm or the wire. A wire falling upon a metal or a grounded arm might be melted and fall from the structure without shutting off the current. The efficiency of a grounded arm and its practical usefulness depend upon the voltage, the current and the circuit breakers.

The construction of high voltage lines and the setting of their circuit breakers is such that the usual types of grounded arms, or grounded poles, when the arms and poles are of metal, would shut off the current without injury to the structure only in case more than one wire of the circuit was affected or the system was grounded. In addition, it is a common practice to "throw-in" the circuit breakers, one or more times, in an attempt to "burn off" a supposititious foreign object on the line. It is within the experience of many engineers that arcs can persist for a considerable period without entirely throwing out the line.

It has sometimes occurred on high voltage lines, without an efficient ground, that an arc has been formed enveloping a large portion of the pole top, with the consequent probability of injury to the structure.

If it can be shown that for certain currents and voltages power wires falling upon an ungrounded wooden arm will not so burn the arm as to cause failure of either the arm itself or of the wires, the grounding requirement would not appear necessary. In case the power wire is provided with a secondary attachment to another insulator, a wire would not fall from the structure, though burned at the primary insulator, and the danger of burning would then be confined to the arm itself.

It has been stated that bringing the earth ground up to the pin concentrates at that point lightning, or surge disturbances from whatever cause, and necessitates a higher grade of insulation.

The carrying capacity of the grounding connection should depend upon the nature and capacity of the power line

It is probable that very different results will be obtained at different voltages, and it seems likely that different requirements will be necessary for different types of transmission line, i. e., that different specifications, or different clauses in the specification, should be used to apply to a high tension line on steel poles and steel arms from those for lower voltages, wooden poles and wooden arms.

Size and Material of Wires:

The desirable qualities in the power wires in so far as the crossing construction is concerned are mechanical strength and tenacity, ability to resist corrosion or other deterioration, and an electrical capacity sufficient to carry, without injury, the current of the line in question.

Theoretically, the necessary breaking strength of a wire for a given span will depend entirely upon the sag, since by increasing the sag the tension in the wire will be reduced approximately in proportion to the sag. Practical considerations, however, indicate a rather indefinite minimum below which it is undesirable to go. Any surface injury, such as local pitting by arcs and nicks from careless handling, or any weakness in the material due to errors in manufacture, will have a relatively greater effect upon a small wire than upon a large one. Similarly, such faults are more serious in solid wires than in stranded cables, and in hard-drawn wire than in soft-drawn wire. In stranded cables an injury to a single strand affects only a fractional part of the main section; in hard drawn wire the surface, or skin material, has approximately twice the unit strength of the interior mass, so that any injury will have a relatively greater effect upon hard-drawn wire. Fortunately, the process of wire drawing insures a large amount of work per unit of mass, so that the finished product is a very homogeneous and trustworthy material. This fact, together with the reduction in stress, due to any increase in sag by stretching, explains the comparative immunity from mechanical failures and raises the question as to whether a low modulus of elasticity is not in reality a desirable feature. It is assumed that the clearances are large enough to permit the increase in sag, due to stretching, a soft-drawn wire, strung with the same factor of safety, would be less likely to fail than a hard-drawn wire.

Since insulated wires are used for low voltage lines and the insulation is a protection against mechanical injury, it would appear that the smallest permissible size should apply to such wires and that they may be solid instead of stranded.

Insulators.

While there is a great difference of opinion as to the relative merits of various makes and types of insulators, and while any definite requirement would seem improper, the following desirable characteristics may be noted, i. e., a conservative insulating capacity for the line in question, freedom from internal stresses and injury by the expansion of ice, mechanical strength against temperature changes and external forces and a smooth exterior surface to assist the cleaning action of rain.

In the case of low voltage lines a higher grade of insulator can be installed at little additional expense, and since the greater number of accidents originate at the insulators, it would seem economical to require a relatively high grade insulator for such lines and omit certain other requirements that may be necessary on high voltage lines where the factor of safety in the insulators is less.

Pins:

On high voltage lines the insulator pins at crossings should be of metal, and there is no apparent reason why any reasonable factor of safety cannot be obtained. There are, however, a large number of low voltage lines using wooden pins; and the possible decay or burning of such pins and their limited mechanical strength has raised a question as to the limiting conditions under which wooden pins are permissible.

In general, the pins should extend well up into the insulator in order to reduce the mechanical stress upon the material of the insulator. On account of the improbability of frequent painting, metal pins should be double galvanized or otherwise protected against corrosion.

It may be noted that some of the long pins now in use would, in case of a broken wire, develop a very large torsional effect upon the crossarm, and an excessive bending stress upon the crossarms on curves.

Tie Wires:

The usual function of the wire "pigtails," used to attach the power wires to the insulators, is to prevent falling, rather than to effect dead ending.

Assuming the most efficient form of tie attachment, there is some unknown relation between the size and number of turns of the tie wire and the size of the power wire which will be dead ended thereby. Further, the efficiency of a tie wire is almost entirely dependent upon the workmanship, and the lineman should be taught to make this attachment without nicking the power wire.

Clamping Devices:

The general theory of the clamping device is to require an efficient insulator, and a positive dead ending attachment of the wire to the insulator through a device having sufficient mechanical strength to resist the tension of the wire in case the insulator fails; that the device should have sufficient mass to resist burning; and that the points of attachment to the power wires be at a sufficient distance from the insulator to minimize the danger from arcs.

The attachment should be so designed that it cannot fall free of the pin in case the insulator is shattered; it should not require delicate adjustment, and should be firmly clamped to the wire without injuring the wire in any way.

It has been claimed that a clamp, by restraining the wire and forming a sharp point of bending as the wire sways with the wind, would promote crystallization and cause the wire to fail. Even in view of the voluminous opinions on this point, as applied to trolley wire ears, it is doubtful whether a clamp with well-rounded orifices would introduce any appreciable injury to the line wire. However, it is entirely practicable to design a clamping device which will allow both vertical and horizontal bending at the insulator rather than at the clamp.

It has been claimed that clamping devices materially reduce the effective arcing distance of the insulators if in the form of caps which envelop the head of the insulators.

Insulated Wire:

Since the crossing construction does not contemplate placing any dependence upon the insulating value of the covering of an insulated wire, the insulation should be carefully removed whenever it is necessary to attach clamps, in order that the clamp may be securely tightened. It is probable that thin bushings of soft copper, aluminum, lead, etc., are advisable throughout the clamps to prevent injury to the surface of the power wire. Similar bushings, or a wrapping of fine wire, may be placed over the insulators and for some distance on either side to prevent pitting the surface of the power wire in case arcs are formed.

Preservative Treatment:

Any approved method of preserving wooden arms and poles is desirable in so far as the life of these parts is concerned. It should, however, be noted that the ease of ignition of the arms in case of arcs, and of the poles in case of grass or other fires, may be increased by preservative treatment.

If the crossing poles are upon a public street the possibility of soiling the clothes of passers-by must be considered.

Wooden poles have sometimes been set in a concrete base in order to prevent decay at the ground line, and while the life of the poles is undoubtedly increased, it would appear better practice to allow the pole to project through the concrete at the butt so that dry rot may be delayed.

Appendix B.

Tables by Fitzpatrick & Coombs, New York.

TABLE I

STEEL WIRE—STRANDED—GALVANIZED

Diam.	Number and Gauge of Wires	Area Square Inches	Ultimate Strength: Guy Wire	Ultimate Strength: Siemens Martin 75,000 ℔	Ultimate Strength: High Tension 125,000 ℔	Ultimate Strength: Ex. High Tension 187,000 ℔	Load Per Lin. Ft Vertical: Dead	Load Per Lin. Ft Vertical: Dead + ½" Ice	Load Per Lin. Ft. Horizontal 8.0 ℔ Per Sq. Ft. ½" Ice	Max. Load Per Lin. Ft Plane of Resultant Class B Loading	E A E = 29,000,000
7/8"									1.250		
13/16"									1.208		
3/4"									1.167		
11/16"									1.125		
5/8"	7-5	0.2356		19,000	25,000	42,000			1.083		6,832,400
9/16"	7-6½	0.1922		14,500	21,100	34,500	0.668	1.329	1.042		5,573,800
1/2"	7-8	0.1443	8,500	11,000	18,000	27,000	0.510	1.132	1.000	1.510	4,184,700
7/16"	7-9	0.1204	6,500	9,000	15,000	22,500	0.415	0.998	0.958	1.383	3,491,600
3/8"	7-11	0.0832	5,000	6,800	10,500	17,250	0.295	0.839	0.917	1.243	2,412,800
5/16"	7-12	0.0606	3,800	4,860	8,100	12,100	0.210	0.715	0.875	1.130	1,757,400

PROPERTIES OF WIRE MATERIAL

	Ultimate Strength Per Square In.	Elastic Limit	Mod. Elasticity E	Coef. Expansion θ
Copper, solid, soft-drawn..........	32-34,000	28,000	12,000,000	0.0000096
" " hard-drawn	50-55-57-60,000	30-32-34-35,000	16,000,000	"
" stranded, soft-drawn......	34,000	28,000	12,000,000	"
" " hard-drawn	60,000	35,000	16,000,000	"
Aluminum, stranded	23-24,000	14,000	9,000,000	0.0000128
Steel, stranded, Siemens-Martin...	75,000		29,000,000	0.0000064
" " high-tension	125,000		"	"
" " ex-high-tension ..	187,000		"	"

Note—Class A loading = dead load + 15.0 lbs. p. sq. ft. wind pressure.
Class B " = dead + ½" ice + 8.0 lbs. wind.
Class C " = dead + ¾" ice + 11.0 lbs. wind.

TABLE II

COPPER WIRE—STRANDED

Gauge B. & S.	Diam. Inches	Area Sq. In.	Hard Drawn Ultimate Tension Lbs.	Hard Drawn Factor 2½ Lbs.	Soft Drawn Ult. Tens'n Lbs.	Soft Drawn Factor 2½ Lbs.	Load per Lin. Foot Vertical: Dead	Dead + ½ Ice	Dead + ¾ Ice	Load per Lin. Foot Horizontal: 15.0 lb P.Sq. Ft.	8.0 lb P.Sq.Ft. ½" Ice	11.0 lb P.Sq.Ft. ¾" Ice	Max. Load per Lin. Foot Plane of Resultant: Class A Load'g	Class B Load'g	Class C Load'g	EA: E 16,000,000	E 12,000,000
500,000	0.819	0.3924	23,540	9,420	13,340	5,335	1.525	2.345	2.989	1.024	1.213	2.126	1.837	2.640	3.668	6,278,400	4,708,800
450,000	0.770	0.3535	21,210	8,480	12,020	4,810	1.373	2.163	2.791	0.963	1.180	2.081	1.677	2.464	3.481	5,636,800	4,242,000
400,000	0.728	0.3141	18,860	7,540	10,680	4,270	1.220	1.984	2.599	0.910	1.152	2.042	1.522	2.294	3.305	5,025,600	3,769,200
350,000	0.679	0.2750	16,500	6,600	9,350	3,740	1.068	1.801	2.401	0.849	1.119	1.997	1.364	2.120	3.123	4,400,000	3,300,000
300,000	0.630	0.2360	14,160	5,665	8,025	3,210	0.915	1.618	2.203	0.788	1.087	1.953	1.208	1.949	2.944	3,776,000	2,832,000
250,000	0.590	0.1965	11,790	4,715	6,680	2,670	0.762	1.440	2.012	0.738	1.060	1.916	1.061	1.788	2.778	3,144,000	2,358,000
0000	0.530	0.1662	9,970	3,990	5,650	2,260	0.645	1.286	1.831	0.663	1.020	1.861	0.925	1.641	2.611	2,659,200	1,994,400
000	0.470	0.1318	7,910	3,160	4,480	1,790	0.513	1.116	1.651	0.588	0.980	1.806	0.780	1.485	2.446	2,108,800	1,581,600
00	0.420	0.1045	6,270	2,510	3,555	1,420	0.406	0.978	1.498	0.525	0.947	1.760	0.664	1.361	2.311	1,672,000	1,254,000
0	0.375	0.0829	4,970	1,990	2,820	1,125	0.322	0.866	1.372	0.469	0.917	1.719	0.569	1.261	2.199	1,326,400	994,800
1	0.330	0.0657	3,940	1,580	2,235	895	0.255	0.771	1.263	0.413	0.887	1.678	0.485	1.175	2.100	1,051,200	788,400
2	0.291	0.0521	3,130	1,250	1,770	710	0.203	0.695	1.174	0.364	0.861	1.642	0.417	1.107	2.019	833,600	625,200
3	0.261	0.0413	2,480	990	1,405	560	0.160	0.633	1.103	0.326	0.841	1.614	0.363	1.053	1.955	660,800	495,600
4	0.231	0.0328	1,970	790	1,115	445	0.127	0.582	1.042	0.289	0.821	1.587	0.316	1.006	1.899	524,800	393,600
5	0.206	0.0260	1,560	625	885	355	0.101	0.540	0.992	0.258	0.804	1.564	0.277	0.970	1.852	416,000	312,000
6	0.184	0.0206	1,235	495	700	280	0.080	0.505	0.951	0.230	0.789	1.543	0.243	0.936	1.813	329,600	247,200

TABLE III

COPPER WIRE—SOLID

0000	0.460	0.1662	8,310	3,325	5,650	2,260	0.641	1.238	1.770	0.575	0.973	1.797	0.861	1.575	2.522
000	0.410	0.1318	6,590	2,635	4,480	1,790	0.509	1.074	1.591	0.512	0.940	1.750	0.722	1.427	2.365
00	0.365	0.1045	5,220	2,090	3,555	1,420	0.403	0.940	1.443	0.456	0.910	1.709	0.608	1.309	2.237
0	0.325	0.0829	4,560	1,825	2,820	1,125	0.320	0.833	1.323	0.406	0.883	1.673	0.517	1.214	2.133
1	0.289	0.0657	3,740	1,495	2,235	895	0.253	0.744	1.223	0.362	0.860	1.640	0.442	1.137	2.046
2	0.258	0.0521	3,120	1,250	1,770	710	0.202	0.673	1.142	0.322	0.838	1.611	0.380	1.075	1.975
3	0.229	0.0413	2,480	990	1,405	560	0.159	0.613	1.073	0.287	0.820	1.585	0.328	1.024	1.914
4	0.204	0.0328	1,960	785	1,115	445	0.126	0.564	1.016	0.255	0.803	1.567	0.284	0.981	1.863
5	0.182	0.0260	1,560	625	885	355	0.100	0.524	0.969	0.227	0.788	1.542	0.248	0.946	1.821
6	0.162	0.0206	1,240	495	700	280	0.079	0.491	0.930	0.203	0.775	1.524	0.218	0.917	1.785

APPENDIX B—*Continued.*

TABLE IV

COPPER WIRE—SOLID, TRIPLE BRAID WEATHER-PROOFING

Gauge	Ext.	Area	Hard Drawn		Soft Drawn		Load per Lin. Ft. Vertical			Load per Lin. Ft. Horizontal			Max. Load per Lin. Ft. Plane of Resultant			EA	
B. & S.	Diam. Inches	Sq. In.	Ultimate Tension Lbs.	Factor 2½	Ultimate Tension Lbs.	Factor 2½	Dead	Dead + ½" Ice	Dead + ¾" Ice	15.0 lb P.Sq.Ft.	8.0 lb P.Sq.Ft. ½" Ice	11.0 lb P.Sq.Ft. ¾" Ice	Class A Load'g	Class B Load'g	Class C Load'g	E 16,000,000	E 12,000,000
0000	0.640	0.1662	8,310	3,325	5,650	2,260	0.767	1.476	2.064	0.800	1.093	1.961	1.108	1.837	2.847	2,659,200	1,994,400
000	0.593	0.1318	6,590	2,635	4,480	1,790	0.629	1.309	1.882	0.741	1.062	1.918	0.972	1.686	2.687	2,108,800	1,581,600
00	0.515	0.1045	5,220	2,090	3,555	1,420	0.502	1.133	1.682	0.644	1.010	1.847	0.818	1.518	2.498	1,672,000	1,254,000
0	0.500	0.0829	4,560	1,825	2,820	1,125	0.407	1.029	1.573	0.625	1.000	1.833	0.746	1.434	2.415	1,326,400	994,800
1	0.453	0.0657	3,740	1,495	2,235	895	0.316	0.909	1.438	0.564	0.968	1.790	0.646	1.328	2.296	1,051,200	788,400
2	0.437	0.0521	3,120	1,250	1,770	710	0.260	0.843	1.367	0.546	0.958	1.775	0.605	1.276	2.240	833,600	625,200
3	0.406	0.0413	2,480	990	1,405	560	0.199	0.763	1.278	0.507	0.937	1.747	0.545	1.208	2.164	660,800	495,600
4	0.359	0.0328	1,960	785	1,115	445	0.164	0.698	1.199	0.449	0.906	1.704	0.478	1.143	2.083	524,800	393,600
5	0.344	0.0260	1,560	625	885	355	0.135	0.660	1.146	0.430	0.896	1.690	0.451	1.113	2.042	416,000	312,000
6	0.328	0.0206	1,240	495	700	280	0.112	0.627	1.118	0.410	0885	1.675	0.425	1.084	2.014	329,600	247,200

TABLE V

ALUMINUM WIRE—STRANDED

Gauge B. & S.	Ext. Diam. Inches	Area Sq. In.	Hard Drawn Ultimate Tension Lbs.	Factor 2½	Soft Drawn Ultimate Tension Lbs.	Factor 2½	Dead	Dead + ½" Ice	Dead + ¾" Ice	15.0 lb P.Sq.Ft.	8.0 lb P.Sq.Ft. ½" Ice	11.0 lb P.Sq.Ft. ¾" Ice	Class A Load'g	Class B Load'g	Class C Load'g	E 9,000,000	
500,000	0.814	0.3924	9,025	3,610			0.460	1.280	1.919	1.018	1.209	2.121	1.117	1.762	2.860	3,531,600	
450,000	0.772	0.3535	8,130	3,250			0.414	1.205	1.834	0.965	1.181	2.082	1.050	1.687	2.775	3,181,500	
400,000	0.725	0.3141	7,225	2,890			0.368	1.130	1.744	0.906	1.150	2.040	0.977	1.612	2.684	2,826,900	
350,000	0.679	0.2750	6,325	2,530			0.322	1.055	1.655	0.849	1.119	1.997	0.908	1.538	2.594	2,475,000	
300,000	0.621	0.2360	5,430	2,170			0.276	0.973	1.555	0.776	1.081	1.944	0.823	1.454	2.489	2,124,000	
250,000	0.567	0.1965	4,520	1,810			0.230	0.894	1.459	0.709	1.045	1.895	0.745	1.375	2.392	1,768,500	
0000	0.522	0.1662	3,820	1,530			0.195	0.831	1.382	0.652	1.015	1.853	0.681	1.312	2.312	1,495,800	
000	0.464	0.1318	3,160	1,265			0.155	0.755	1.288	0.580	0.976	1.800	0.600	1.234	2.213	1,186,200	
00	0.414	0.1045	2,510	1,000			0.122	0.691	1.208	0.518	0.943	1.754	0.532	1.168	2.130	940,500	
0	0.368	0.0879	1,990	795			0.097	0.637	1.140	0.460	0.912	1.712	0.470	1.112	2.057	746,100	
1	0.328	0.0657	1,575	630			0.077	0.592	1.082	0.410	0.885	1.676	0.417	1.065	1.995	591,300	
2	0.291	0.0521	1,250	500			0.061	0.533	1.032	0.364	0.861	1.642	0.368	1.023	1.939	468,900	
3	0.261	0.0413	990	395			0.049	0.522	0.992	0.326	0.841	1.614	0.329	0.990	1.894	371,700	
4	0.231	0.0328	790	315			0.039	0.494	0.954	0.289	0.821	1.587	0.292	0.958	1.846	295,200	

*"Overhead Construction for High-Tension Electric Traction or Trans-mission," by R. D. Coombs, Trans. Am. Soc. C. E., Vol. LX.

APPENDIX C.

CATENARY STRESSES.

ENDS OF SPAN AT SAME ELEVATION.

S = span in feet
d = sag in feet
W = load p. lin. ft. in plane of wire
A = area of wire, in sq. inches
E = Modulus of elasticity
θ = coef. of expansion
t = change of temperature, degrees
e = elongation or change of length, within elastic limit
Lo = length in feet of imaginary wire ($\omega = 0.$) at normal temp.
Loc = " " " " cold—80° F. below normal temp.
Loh = " " " " hot—70° F. above " "

Index to subscripts

no subscript = normal conditions
c = cold 80° F. below normal + dead load
i = " " ice load + "
cw = " " wind load + "
iw = " " ice + wind + "
h = hot 70° F. above normal + "

Note

Wiw, is the resultant of the vertical dead + ice loads and the horizontal wind load

Wcw, is the resultant of the vertical dead load and the horizontal wind load.

Stresses

Substitute normal values in equations 1. 2 3 4.

Assume values of Th, Tiw, Tc. Ti or Tcw, such that equations 5 and 6 will give identical values of dh, diw, and etc.

The tension that will give the same sag by eq. 5 and 6 (independently) is the tension resulting from that sag and the given loading.

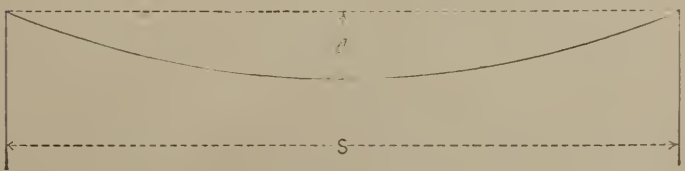

FIG. 2.

CATENARY STRESSES

ENDS OF SPAN AT SAME ELEVATION

$$T = \frac{WS^2}{8d} \quad (1) \qquad L = S\left[1 + \frac{8d^2}{3S^2}\right] \quad (2)$$

$$e = \frac{T\,L}{E\,A} \quad (3) \qquad Lo = L - e \quad (4)$$

(70° F. above normal, dead load.)

$$Loh = Lo\,(1 + \theta th) \qquad eh = \frac{Loh \times Th}{E\,A} \qquad Lh = Loh + eh$$

$$dh = 0.612\sqrt{S\,(Lh - S)} = \quad (5)$$

$$dh = \frac{Wh \times S^2}{8\;Th} = \quad (6)$$

(80° F. below normal, dead + ice + wind loads.)

$$Loc = Lo\,(1 - \theta tc) \qquad eiw = \frac{Loc \times Tiw}{E\,A} \qquad Liw = Loc + eiw$$

$$diw = 0.612\sqrt{S\,(Liw - S)} = \quad (5)$$

$$diw = \frac{Wiw \times S^2}{8\;Tiw} = \quad (6)$$

(80° F. below normal, dead load.)

$$Loc = Lo\,(1 - \theta tc) \qquad ec = \frac{Loc \times Tc}{E\,A} \qquad Lc = Loc + ec$$

$$dc = 0.612\sqrt{S\,(Lc - S)} = \quad (5)$$

$$dc = \frac{Wc \times S^2}{8\;Tc} = \quad (6)$$

(80° below normal, dead + ice loads.)

$$Loc = Lo\,(1 - \theta tc) \qquad ei = \frac{Loc \times Ti}{E\,A} \qquad Li = Loc + ei$$

$$di = 0.612\sqrt{S\,(Li - S)} = \quad (5)$$

$$di = \frac{Wi \times S^2}{8\;Ti} = \quad (6)$$

(80° below normal, dead + wind loads.)

$$Loc = Lo\,(1 - \theta tc) \qquad ecw = \frac{Loc \times Tcw}{E\,A} \qquad Lcw = Loc + ecw$$

$$dcw = 0.612\sqrt{S\,(Lcw - S)} = \quad (5)$$

$$dcw = \frac{Wcw \times S^2}{8\;Tcw} = \quad (6)$$

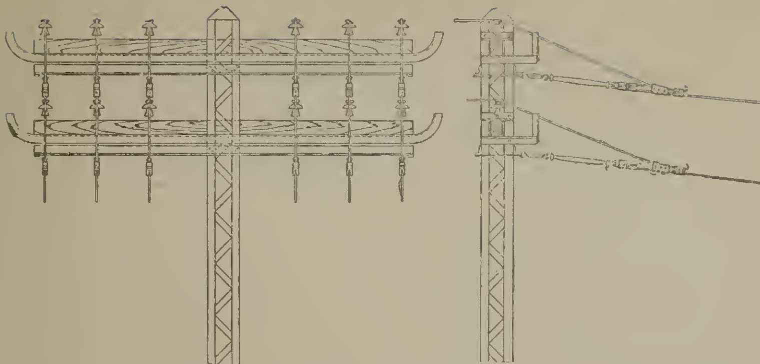

FIG. 3—CLAMPING DEVICE OF N. Y. C. & H. R. R. R. SPEC., APR., 1909

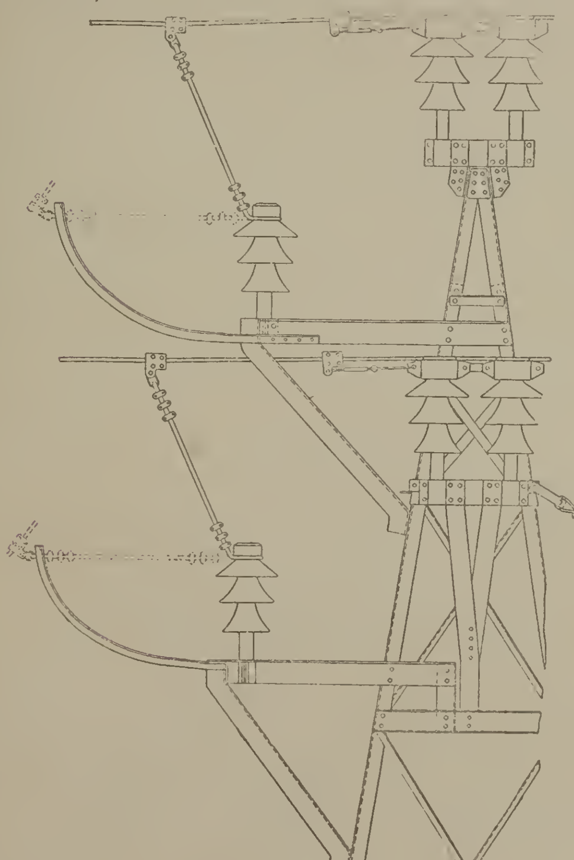

FIG. 4—CLAMPING DEVICE OF N. Y. C. & H. R. R. R. SPEC., APR., 1909.

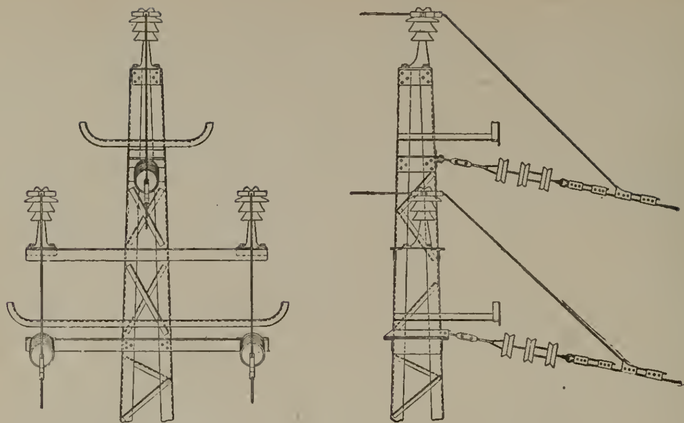

Fig. 5—Clamping Device of N. Y. C. & H. R. R. R. Spec., Apr., 1909.

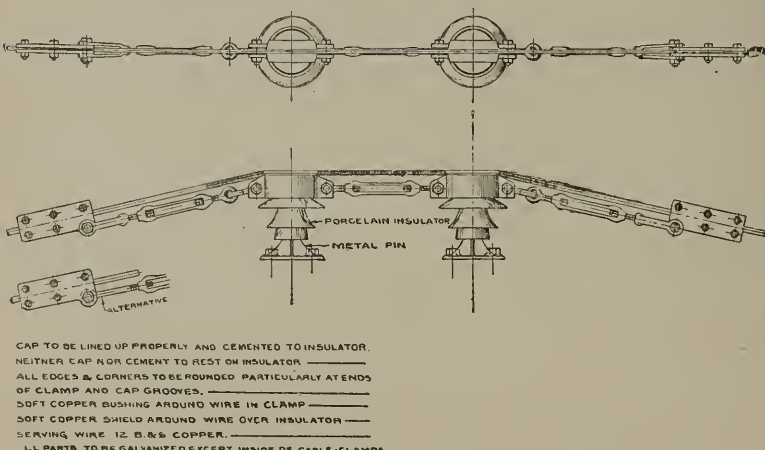

Fig. 6—Clamping Device of P. R. R. Spec., Sept. 1, 1908.

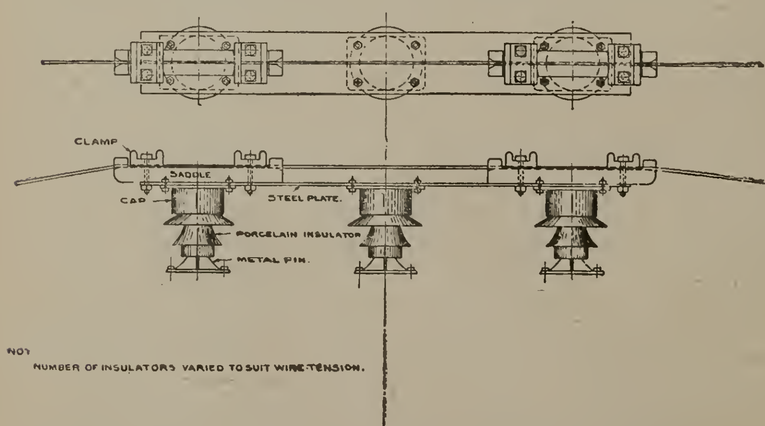

Fig. 7—Clamping Device of P. R. R. Spec., Sept. 1, 1908.

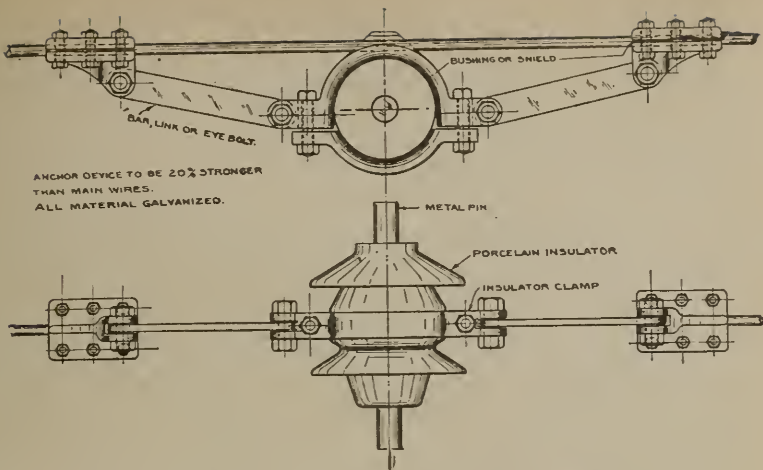

FIG. 8—CLAMPING DEVICE OF P. R. R. SPEC., SEPT. 1, 1908.

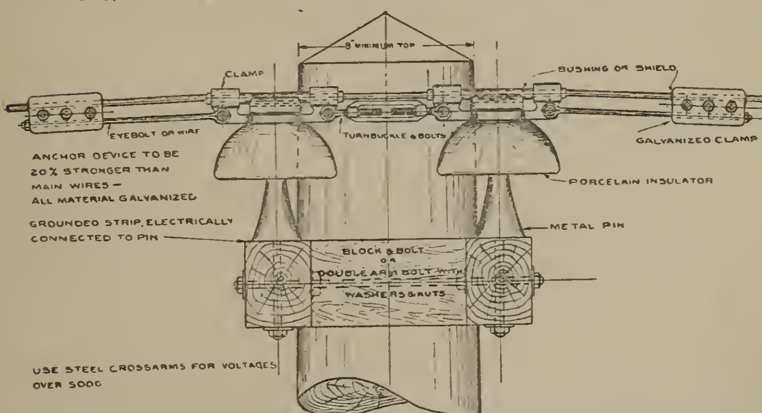

FIG. 9—CLAMPING DEVICE OF P. R. R. SPEC., SEPT. 1, 1908.

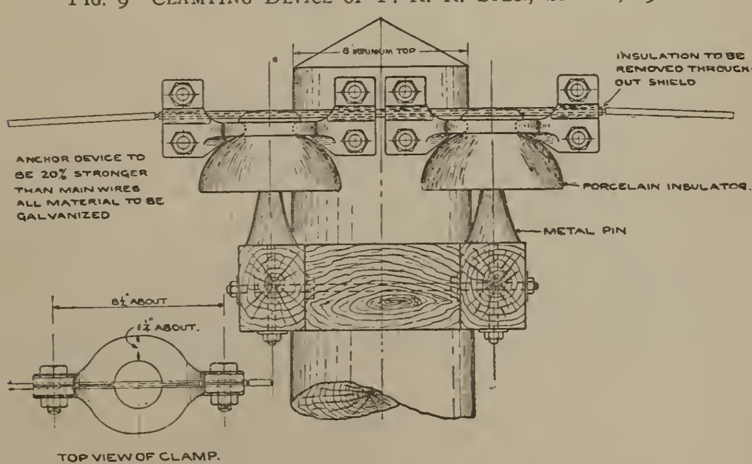

FIG. 10—CLAMPING OF P. R. R. SPEC., SEPT. 1, 1908.

FIG. 11—A CLAMPING DEVICE.

FIG. 12—A CLAMPING DEVICE.

FIG. 13—A CLAMPING DEVICE.

DISCUSSION.

(The report of the Committee on Electricity was presented by the Chairman, Mr. George W. Kittredge, Chief Engineer, New York Central & Hudson River Railroad.)

Mr. George W. Kittredge (New York Central & Hudson River) :— In introducing the report of the Committee on Electricity, which possibly you have not all read, it occurs to me that the letter which Mr. Berg, our late President, addressed to the Committee, at the time the formation of the Committee was first discussed, might be read to very good advantage now, and with your permission I will read it:

"In accordance with resolutions adopted by the Board of Direction of the American Railway Engineering and Maintenance of Way Association on March 16, 1908, for the appointment by the President of a Special Advisory Committee to report direct to the Board of Direction on the necessity for and advisability of establishing a standing committee of the Association to consider and report on special questions connected with the electrified sections of steam railroad systems, I hereby appoint you on such Special Advisory Committee and will ask Mr. Kittredge to act as Chairman.

"The work of the Special Committee will be only advisory to the Board of Direction and, so to say, confidential in the nature of preliminary expert advice to assist the Board in reaching its decision.

"The Special Committee should aim particularly to take a broad view of the question as affecting the Association as a whole and the interests represented by the entire body of members, as also the possible comment that such a step, unless carefully considered and defined, might produce in the minds of many of our valued members and the steam railroad world.

"The mere fact that certain steam railroad systems have electrified sections of their roads and that a limited number of our members, being in close and daily touch with the new conditions, feel the necessity for joint study of certain conditions, should not be considered as the main controlling factor in determining the necessity and desirability of the appointment of such a Standing Committee.

"Similarly, the Special Committee should give careful consideration to the question of not allowing our Association to overstep the limits of its legitimate field of work.

"My individual view is that, if the Standing Committee is appointed, its work should be limited to investigating and reporting on the special characteristic requirements and new conditions in the design, construction and maintenance of track and transmission structures of steam railroad systems operating electric equipment on certain sections of their road.

"It is suggetsed that the Special Committee, in addition to discussing the general questions of the necessity for and the desirability of appointing such a Standing Committee, should outline the scope of the work for such a Standing Committee, with mention of typical cases or subjects so as to illustrate their views by concrete examples.

"The Special Committee should also consider whether the appointment of such a Standing Committee might not preferably be postponed for one or more years, even if they are convinced that eventually such an action will become imperative. On the other hand the appointment at an early date might be considered largely as educational and to give the Standing Committee time to find itself.

"Finally, it is desirable for the Special Committee to make a recommendation as to a distinctive short name for the Standing Committee, if appointed, as also a brief outline of its scope of work and subjects for consideration, suitable for publication as the instructions for the guidance of the Standing Committee, if appointed.

"Under the resolution referred to above, the Board specified on or before December 31, 1908, as the date for the Special Advisory Committee to report to the Board. I call attention that the Board now expects to hold a meeting on November 17, 1908, in Chicago, at which the report of the Special Committee could be considered if presented before that date.

"I will be glad to hear from you whether you will accept the appointment on this Special Advisory Committee, and on receipt of answers will advise Mr. Kittredge accordingly, and request him to take such further action as he may think proper in regard to calling the Committee together."

The Special Committee reported and recommended that a Standing Committee should be named. The Standing Committee was appointed, and this is the first report that is advanced to conclusions. Your standing Committee on Electricity has had several meetings during the year, as outlined in the body of the report, Subcommittees have been appointed on Clearances, on Transmission Lines and Crossings, on Insulation, Maintenance Organization, Electrolysis, Relation to Track Structures, that have been at work with more or less progress during the year and with the exception of Electrolysis, have made reports of grater or less length, which are detailed. Unless there is some reason for the contrary, I would pass to the conclusions of the whole Committee.

In view of the fact that the American Railway Association has a Committee on Clearance Lines, which is to report in April, and the American Electric Railway Engineering Association has also a Committee on Clearance Lines, which will report soon, and because of the fact that your Committee on Electricity was not able, on account of various and sundry reasons to reach conclusions with them and agree upon lines which were satisfactory to all concerned, our Committee desires to move clauses 2 and 3 (the lines shown on Diagram as Third Rail Clearances, and the lines shown on Diagram B as Equipment Clearance Lines) from sub-heading "A" into sub-heading "C," and consider them as reports of progress. It is hoped and expected that we can before the next meeting agree with these other associations upon lines that will be satisfactory to all. Unless there is some further discussion, I would move for adoption the recommendations of the Committee under the head of "Definitions."

The President:—We will read the definitions submitted to the Committee. The first definition reads:

"Third Rail Clearance Lines.—Lines beyond which no part of the third-rail structure shall project."

If there is no objection to the definition as read, it will be considered approved.

The second definition reads:

"Equipment Clearance Lines.—Lines beyond which no part of the equipment shall project. Allowance to be made by equipment manufacturer of new equipment for wear on journals and brasses, on axle collars, on rail, on wheels, compression of springs, sagging of center of car, constructional variations, end play, broken springs, etc."

Mr. Kittredge:—I would like to say that that definition is an important one, as having a bearing later on the establishment and adoption of "clearance lines."

The President:—If there is no further discussion on the definition of "Equipment Clearance Lines," it will be approved. The next definition is:

"Third Rail Gage.—Distance, measured parallel to plane of top of both running rails, between gage of running rail and center line of third rail."

Mr. J. C. Mock (Detroit River Tunnel Company):—I would like to have an explanation of that definition. We have been accustomed to using the center line of the third rail. Just what is meant by the gage line of third rail?

Mr. George Gibbs (Pennsylvania Tunnel & Terminal Railroad):—In trying to define any third-rail gage, the important point should be kept in mind that we are working in very close clearances, and we are trying to harmonize close dimensions on both sides. The center line of the third rail does not fix any clearance point, for the reason that the rail may be two or four inches wide, making a difference of as much as an inch in the clearance point, which is the inner corner of the rail, therefore the gage should be measured from the corner, not the center.

Mr. C. C. Anthony (Pennsylvania Railroad):—As this is a definition of third-rail gage, and gage is distance between two lines, should not the word line appear in both cases in the body of the definition,—"between gage line of running rail and gage line of third rail"? And if that is admitted, will it not then be necessary to define the gage line of the third rail?

Mr. C. E. Lindsay (New York Central & Hudson River):—I think it will be necessary to adopt the same measuring point on the third rail as we do on the running rail. The gage is measured at a point five-eighths of an inch below the top of the running rail, and that same distance should be adopted for the measuring point on the third rail.

Mr. Edwin B. Katte (New York Central & Hudson River):—Because of the very wide variation in the cross-section of the third rails used by railways, the line measured one-half inch from the top or bottom of the rail would not be a definite line. It would seem to me it should be the distance between the perpendicular tangent to the third rail and the gage of the running rail.

Mr. Mock:—It seems to me necessary to add something. You have a standard and also a great many variations from the standard in third-rail construction. In defining this a standard section of third rail should be used, because to take care of the various sections it is impossible to get this gage line at a distance one and one-half inches, unless it is calculated on some standard section.

Mr. Gibbs:—As a matter of fact, the third rail is always made with a vertical head; therefore the side line of the head may be taken as the gage point.

Mr. Katte:—I was thinking, when I spoke, of the variation in sections and more particularly of the special sections of an under-running third rail, as, for instance, the third rail side inclines, where, at the gage line, the section is a mere edge. What we are interested in is a question of clearance, and it seems to me that we want to know what space is available between the vertical plane of the third rail and the gage of the track rail, regardless of whether the third rail is set back for side inclines of an under-running rail or of a top-contact rail. By "gage" I think it is generally understood as being the distance between the verticals.

Mr. Anthony:—I made two points when I spoke before, but I would like to emphasize particularly one, that this definition as it stands is not correct, in that third-rail gage is defined by third-rail gage. I cannot see why the word "line" should not appear twice in the gage definition—"gage line of running rail and gage line of third rail."

Mr. Gibbs:—Of course, Mr. Anthony is entirely correct when he states that the word you are defining should not appear in the definition. However, the gage of a track rail is a well-known term, and we are now simply trying to define the measurement between that point and a similar point on the third rail, and if we use the term "gage," which is well understood, it will briefly define what we are getting at, and avoid a lengthy definition. Of course, I realize the criticism is well founded, as a general thing.

Mr. W. M. Camp (Railway and Engineering Review):—It seems to me that this is a definition which should be considered pretty carefully. In gaging ordinary rails we have the rails right side up, but with the third rail we may have that rail standing with the head upwards or with the head downwards. It strikes me that it is important to understand just what we are getting at here. Do we want the gage of the third rail for the purpose of clearance, or is it desired for the purpose of conforming to the reach of the collector shoe from the car? If that is the requirement, then the center of the third rail would be a more desirable point to measure to than the gage line of the head; and then, again, if the rail is inverted or placed with the head downward, the measurement to that head for gage purposes might not be satisfactory, because then the base of the rail might come nearer to the gage line of the running rail than does the head. I would like to ask the chairman what the purpose of this gage is. Is it to determine clearance or the proper distance from the running rail for the working of the collector shoe? Clearance is one thing and the working gage of the collector shoe is another, and the two should not be confused.

Mr. Kittredge:—For both purposes. It is essential for one and essential for the other, too.

Mr. Charles S. Churchill (Norfolk & Western):—I wish to second the motion of Mr. Anthony, not that it is important to us as railroad men in understanding what the gage is, but because of the fact that we want to have the definition complete in itself, so that anyone not having been present here can understand what is meant. I think the insertion of the word "line" in two places, as recommended, is correct.

Mr. G. A. Mountain (Canadian Railway Committee):—I would suggest the words, "between the gage side of the running rail and center line on third rail," be used.

Mr. Kittredge:—The Committee is willing to accept Mr. Anthony's amendment by inserting the word "line" after the word gage, in each case, in the last line of the paragraph.

Mr. Mountain:—I suggested using the words, "the gage side of the running rail," instead of the word "line."

Mr. Kittredge:—As chairman of the Committee, I would say the word "line" is better than the word "side."

Mr. Hadley Baldwin (Cleveland, Cincinnati, Chicago & St. Louis):—To establish the clearance distance, why not omit the words "gage of" in the second instance. The distance between the gage line of running rail and the third rail is what we are trying to define, as I understand it.

Mr. Gibbs:—The important point of the third rail is the side of the head toward the track, which establishes the point where we must place the approach blocks or side inclines on which the shoe will rise in approaching an isolated section of rail at a turnout. The top corner and side on the contact part of the rail is the important point which we must fix; the other parts will take care of themselves.

Mr. Mock:—I still think, in view of the great variety of sections, the shoe contact line is the thing to be established between the running rail and a clearance line. The distance from the standard rail to the gage line of third rail is, by this definition, to my mind, not fixed because of the great differences of rail sections. It seems to me the shoe line should be fixed, and then, whatever the form of rail, it must be placed in proper relation to that.

Mr. Kittredge:—There should not be a confusion between the gage line and the clearance line. The gage line of the third rail is not necessarily any clearance line, either for equipment or structures, and I fail to catch just the meaning of Mr. Mock's remarks. It was for the purpose of fixing some point definitely that we made this definition as we have.

The President:—For the benefit of the Association I will read the definition of "gage of track" in the Manual:

"Gage (of Track).—The distance between the heads of the rails measured at right angles thereto at a point ⅝ in. below the top of the rail."

Mr. Kittredge:—It would be possible to modify this definition further by saying that the gage line should be in a plane which shall pass vertically through a point in the head of the third rail five-eighths of an inch distant from its working side. We did not think it necessary to put that in the definition, but still that can be added if it is needed for more accurate description of the point through which the line must pass.

Mr. R. G. Kenly (Minneapolis & St. Louis) :—It seems to me that that definition should be left as it was originally, that the measurements should be to the center of the third rail. You start off with the definition of third-rail clearance lines, and, from the chairman's remarks, it is necessary that the reach of the contact shoe shall go to a certain point. Now, these third rails, as I understand them, are of various designs. Some are rails inverted, some are rails right side up, some of them are flat strips of metal, I believe. There is no place to measure the gage on a strip of metal or a piece of metal 2 by 4, so if this third rail, as Mr. Camp remarks, is inside of the clearance lines of the third rail, as defined in the first definition, will it not meet all the requirements? Whatever the width of that rail or whatever the projection of that third rail is toward the running rail, so long as it is outside of the clearance lines, will it not meet all the requirements and will it not define the reach of the contact shoe? which I understand is necessary and at a necessarily fixed distance; that it does not make any difference how wide the third rail is so long as it is outside of your third-rail clearance lines, and therefore the best distance that you can get for that third rail is to the center of it, and not to any inside measurement line.

The President:—How would you fix any definite point, then, that the center of the rail shall be from the gage side, because you will have to take into consideration the varying widths of rails?

Mr. Kenly:—Take the definition as it was originally written.

The President:—Then you would have to fix a certain distance, if you fix that for a rail having a two-and-one-half-inch head; that distance would not be the same as for one having a two-and-one-quarter-inch head.

Mr. Kenly:—Suppose the width did not come inside of the clearance line of the third-rail clearances as defined in the first definition?

The President:—You could not establish a fixed distance, then, to which the center of that rail could be from the gage side of the running rail.

Mr Kenly:—You could, if it should be necessary to do it, to make the reach of the contact shoe a certain distance.

The President:—It is very important, in clearances, to establish a definite clearance.

Mr. Kenly:—I understand the thing to be determined is the third-rail clearance lines, not the location of the third rail itself. The principal thing to be fixed, as I understand, is the clearance lines of the third rail, and its supports. Then the next is to get the third rail location, so that your contact shoe will reach it, and if the center line of that third rail is measured from your gage line, will not that fix the whole thing?

Mr. Lindsay:—I think one great difficulty with the adoption of the center line as the measuring point is the fact that rails are not all symmetrical around the center line, and where you have an unsymmetrical section, it is difficult to say what is the center line.

A Member:—I think we should drop the gage of the track as a point to measure from to the third rail; but take the center of the track and say that no part of the third rail above a certain level shall be closer to the center of the track than a certain distance.

Mr. Kittredge:—It occurs to me that that is fixing the third rail clearances, and not defining third rail gage. This definition is for third rail gage, and not defining clearances.

Mr. Camp:—That is just the point I am getting at, and I do not believe we can make this definition suitable to both clearance and gage. I understand Mr. Kittredge to say that the rail might be at gage and still there might not be the desired clearance. Here is the point: is it not desirable that the center of the contact shoe shall center with the third rail?

Mr. Gibbs:—No.

Mr. Camp:—This gage is to be used for laying the third rail. In other words, when the third rail is installed it must be laid to a certain gage. What is the gage line of the third rail? Is it at some point on the head or on the base, or on some other part? In establishing clearance it is necessary to measure to the nearest part of the third rail, but if we are going to gage it for the proper working of the collector shoe, then we must put to gage that part of it which comes in contact with the shoe. I do not see, unless something more is added, how we are going to make the definition cover both clearance and gage. Perhaps the addition of the word "head," so that it would read: "the gage line of the third rail head," etc., would help out. But I want to make this point: if we are going to gage the third rail for clearance, we must measure to the nearest point on that rail from the track rail or so-called running rail.

Mr. Kittredge:—It is important that you have that distance for clearance purposes.

Mr. Camp:—Certainly. We are bound to have clearance, anyhow; that is a fundamental requirement.

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis):—As I understand it, definition No. 1, on each side of the track, will be two lines; the third rail would have to be placed within these two lines. Under definition No. 3 will be located the gage line of this third rail, and between these three lines you would have to design a rail that would fit.

Mr. C. H. Ewing (Atlantic City Railroad):—The subiect-matter to be determined is not a standard gage distance. I do not think that that can be secured. The gage distance varies according to the type of rail that you use. For instance, on the sketches shown in the report the third rail on the Hudson & Manhattan Railroad will require an entirely different gage than the one on the preceding page of the Grand Rapids Railroad, so that the purpose of this definition is simply to indicate where measurements shall be taken; and it appears to me that, in view of the fact that there cannot be any standard gage adopted, that perhaps the best measurement can be secured from the center of the rail rather than from the side.

Mr. W. H. Elliott (New York Central & Hudson River) :—Does not this definition try to cover two things: one, the gage, which is the distance between two lines, and the other, the definition of the gage line for the third rail? Either there should be a definition added for the gage line of the third rail or the definition should read: "the distance measured parallel to plane of top of both running rails, between gage line of running rail and nearest line of third rail."

Mr. Gibbs:—It is difficult to explain to the Association without diagrams just what we are after. In locating a third rail, the shoe must be so adjusted that it has sufficient contact area on the top of the rail (or on the bottom of it). That generally means that the shoe shall lap over about two-thirds of the width of the head. In addition to that, cross-overs, switches, where you pass from one section of third rail to another, a very important consideration is that of getting the shoe, which is hanging down off of the rail, up onto the rail as it approaches.

Mr. H. T. Porter (Bessemer & Lake Erie:—We have passed the second question, but I will not take more than a minute of your time. "Allowance" starts the second sentence. Should not that be "shall be" or "will be?"

The President:—The Committee recommends the words "must be" instead of "to be." The definition as amended will be approved. The next is:

"Electrical Supervisor.—An officer on the division staff qualified to supervise the maintenance of the electrical transmission and working conductors outside of the power station."

Mr. Kittredge:—The Committee would add to that, "and Sub-Stations—outside of power stations and sub-stations."

The President:—If there is no further discussion on the definition, it will be accepted as amended. The next definition is:

"Bonders.—Employes qualified to maintain rail and other bonds and their appurtenances.

"Traction Linemen.—Employes qualified to maintain wires and cables and their appurtenances for all railroad voltages."

Mr. Porter:—Should not there be an additional word besides "qualified" in the last definition? A man may be qualified and not have the job.

Mr. Mock:—Would it not be acceptable to say, "an employe whose duty it is?"

Mr. Kittredge:—The man may be out of a job. A traction lineman is a man qualified to do.

The President:—If there is no further discussion on this definition, it will be accepted as submitted. The next definition is headed "Patrolmen."

"Patrolmen.—Employes qualified to inspect and make minor repairs to track and third-rail structures, cables and wires, and to use hand signals for the protection of trains."

The President:—If there is no objection to that definition, it will be accepted as submitted.

(The President then read the paragraph headed "Bond," which was accepted as submitted.)

(The President next read the paragraph headed "Cable," which was accepted as submitted.)

The President:—Conclusions 2 and 3 will be referred back to the Committee, as they are only submitted as a progress report.

(The President then read paragraph 4.)

"(4) The principle that electric maintenance should, as far as possible, be performed by existing Maintenance of Way Organization with such modifications as may be necessary."

Mr. William McNab (Grand Trunk):—It seems to me that the word "existing" is not necessary. What is existing to-day may not be existing six or twelve months from now. Will you not cover the same ground if you leave the word "existing" out?

Mr. Kittredge:—I do not see that it is essential that that word shall be taken out. As a rule the installation of electrical operation comes about after the steam operation. It is not necessary that it should, but in the majority of cases it does, and the idea expressed by this is that a new organization for maintenance is not essential; that any existing organization can be developed and expanded and brought up to the point where it can take care of electrical organization as well as steam organization.

Mr. McNab:—I do not think that it is essential. I think you will cover the same ground by leaving out the word "existing."

Mr. Mock:—I would favor omitting that word.

Mr. Kenly:—As I understand this proposition, the electrical maintenance is on a somewhat higher plane than the ordinary maintenance of track or signals, and it is the intention of this rule to give the employes of the signal department, or even the ordinary roadway department, an opportunity to be promoted, if they show the ability to take charge of this electrical work. I favor leaving the word "existing" in.

Mr. Anthony:—I will support the Committee, provided the Committee will show clearly that this applies to steam roads which have been electrified.

Mr. McNab:—I move that the word "existing" in this paragraph be left out.

(The motion was lost.)

(The President then read paragraph 5.)

"(5) A Maintenance of Way organization, shown on diagram A, will be productive of efficient results."

Mr. Kittredge:—I suppose there is more opportunity for intelligent and otherwise discussion on that question than on any other conclusion that this Committee has recommended. The plan that has been outlined in this paragraph is a plan of organization. We don't say that it is the only plan; we don't say that it is the best plan. It is a plan which will bring forth efficient results. The conditions which exist on one railway may be very different from those which exist on other railways, and it may be necessary to enlarge or curtail certain parts of the organization to a greater extent than is here suggested. You may be able to unite in one person the duties of three or four persons named here.

Mr. J. B. Austin, Jr. (Long Island Railroad):—We have been talking about third rail organization, and not about the signal organization. If you want to bring your signal engineer under your electrical engineer, that is a matter for each road to settle for itself.

Mr. Lindsay:—The Committee purposely eliminated the signal side of the question from its outline of organization. Signaling is, in itself, a great and important specialty, and there is nothing in this outline of organization that interferes in any way with the introduction of the electrical signal system.

Mr. B. H. Mann (Missouri Pacific):—It is not clear to me, in connection with the definition of the electrical supervisor, as to his duties. I know that he is qualified to do certain things, but when it comes time to have those things done, he must go to a co-ordinate officer, the Master Carpenter. He is in a sense responsible under this title of electrical supervisor, but if he wants a wire repaired, and the men who repair the wires are repairing a building, is it necessary for him to go to a Division Engineer and ask that the Master Carpenter be instructed to do the work?

Mr. Kittredge:—In the definition of electrical supervisor, we have made no attempt to describe his duties; we describe the man. An electrical supervisor on one road may confine his attention to one or two things. On another road he may be a very busy man and have no title, not even electrical supervisor, and still be the electrical supervisor.

Mr. Mann:—May I ask for information, if it is an error in the diagram in not having a vertical line connecting the electrical supervisor with the men who do that part of the technical work?

Mr. Kittredge:—The electrical supervisor is connected through the supervisor of bridges with the men who actually do the work. There is a horizontal line connecting the electrical supervisor through the supervisor of bridges, down through the men who come under him.

Mr. Gibbs:—That is when inspecting a device; he does not do any work.

The President:—If there is no further discussion on this report, and there is no objection to the conclusions of the Committee, as now amended, they will be accepted, and the Committee excused with the thanks of the Association.

REPORT OF SPECIAL COMMITTEE ON BRINE DRIPPINGS FROM REFRIGERATOR CARS.

(Bulletin 129.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee has held one meeting during the year and are pleased to report that this Association's former request to the American Railway Association to take some action to stop drippings from refrigerator cars was the principal cause for renewed activity on the part of the Committee of the Master Car Builders' Association on this subject. In June, 1909, a Committee from the American Railway Engineering and Maintenance of Way Association, consisting of Messrs. C. H. Ewing, F. E. Schall, E. G. Lane and L. C. Fritch, attended a meeting of a Special Committee of the Master Car Builders' Association at Atlantic City. In his report of this meeting, Mr. Fritch stated that the Master Car Builders' Association was experimenting with a plan which provides that the brine drippings from refrigerator cars be retained in the tanks inside of the cars between icing stations and the tanks emptied at icing stations or points where cars are usually re-iced.

The tests to that date were not satisfactory, but they were to be continued under extremely high temperature conditions. Accordingly, in August, 1909, the Committee conducted an eight-day test at the Armour Car Line shops, Chicago. The tests extended from August 4 to August 11, inclusive. The maximum temperature was 94 degrees, between four and five o'clock, August 8. The Committee states the tests justify them in making the following recommendations:

"1. All salt-water drippings should be retained in the ice tanks and drained off only at icing stations.

"2. The total capacity of drain openings should not exceed the capacity of traps, and the capacity of drains and traps should be sufficient to release all drippings within the time limit of icing the train.

"3. The mechanism adopted for handling drain valves should be simple and positive, and so designed as to insure closing the valves before hatch plugs can be returned to their places.

"4. Salt drippings should be conducted from ice tanks through the drain valves above described and thence to the outside of cars through the regular traps and drain pipes.

"The packing companies have co-operated with your Committee in their investigation, and have expressed their willingness to put into effect the practice recommended by your Committee, if these recommendations meet with the approval of the Master Car Builders' Association."

As the above report was approved by the Master Car Builders' Association, June, 1910, your Committee is of the opinion that the present status of the subject does not require submitting of further data, showing the damage caused to railroad property because of the present practice, and concludes:

(1) That this Association should request the American Railway Association to approve the recommendations of the Master Car Builders' Association as satisfactory.

(2) That this Association should request the Maintenance of Way Departments to provide the facilities needed to dispose of the brine drained from cars at the re-icing stations.

(3) That the purpose for which this Committee was appointed has been accomplished and, therefore, the Committee should be dismissed.

Respectfully submitted,

J. C. Mock, Chairman;
C. H. Cartlidge,
C. B. Hoyt,

Committee.

DISCUSSION.

(The report on Brine Drippings from Refrigerator Cars was presented by the Chairman, Mr. J. C. Mock, Electrical Engineer, Detroit River Tunnel Company.)

Mr. Mock:—It seems to me that all that is necessary is to read the recommendations of the Committee, which are as follows:

"(1) That this Association should request the American Railway Association to approve the recommendations of the Master Car Builders' Association as satisfactory.

"(2) That this Association should request the Maintenance of Way Departments to provide the facilities needed to dispose of the brine drained from cars at the re-icing stations.

"(3) That the purpose for which this Committee was appointed has been accomplished, and therefore the Committee should be dismissed."

The President:—The report of the Committee is before you for discussion. I think the thanks of this Association and of the railroads generally are due to the Master Car Builders' Association Committee and the Committee of this Association for finally reaching a conclusion on this matter.

Mr. R. G. Kenly (Minneapolis & St. Louis):—I take exception to just one point in the report, that this Association shall ask the American Railway Association to do certain things. I think if we pass this report up to the American Railway Association as having been adopted by this Association, we have done our duty, and we should not attempt to influence that Association by telling them what to do. I think we should simply adopt the report, as the sentiment of this Association, and let it go to the American Railway Association for what it is worth.

The President:—If the American Railway Association approves the report of the Master Car Builders' Association, this question might be expedited. The Master Car Builders' Association has already submitted a report to the American Railway Association, and it seems that it would be proper for us to request prompt action in the matter in order that we may get relief from this burden. The Committee of the Master Car Builders' Association did most of the work, and they are entitled to the credit for it. It appears to the Chair that the conclusions of the Committee are very well taken.

Mr. J. M. Meade (Santa Fe):—I would like to ask the members of this Association if anyone knows of anything that is in use at the present time to protect steel and iron bridges from corrosion due to brine drippings? I ask this as information.

The President:—I think that matter is a little out of order, and can properly be taken up under one of the other Committees, such as the report of the Committee on Iron and Steel Structures.

(On motion, the report of the Committee was adopted.)

Mr. W. H. Courtenay (Louisville & Nashville):—As a matter of information I would inquire whether the Secretary of this Association will address a communication to the American Railway Association, informing it of the action taken at this meeting? I would like to know what steps will be taken in this matter.

The President:—The Association will carry out officially the conclusions reached by the Committee, and adopted by the convention. A communication will be sent to the American Railway Association. The Committee is relieved, with the thanks of the Association.

REPORT OF COMMITTEE XIV.—ON YARDS AND TERMINALS.

(Bulletin 129.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Yards and Terminals submits herewith its Eleventh Annual Report.

A meeting was held at Niagara Falls, N. Y., September 16 and 17, 1910, at which the following named members were present:

F. S. Stevens, Chairman;	H. A. Lane,
W. C. Barrett,	B. H. Mann,
A. H. Dakin, Jr.	A. Montzheimer,
M. J. Henoch,	C. H. Spencer,
G. H. Burgess,	E. B. Temple.

The subjects assigned by the Board of Direction and the plans to accompany the report were discussed at great length and decisions reached on all points on which differences of opinion were found to exist.

The Committee on Signals and Interlocking was represented by Mr. W. J. Eck, who participated in our discussions and approved our proposed plans for track layouts as being well designed for interlocking and signaling.

The subjects assigned by the Board of Direction for our consideration and report were as follows:

(1) Consider revision of Manual; if no changes are recommended, make statement accordingly.

(2) Development of mechanical handling as a means of promoting rapidity and economy in the handling of freight.

(3) Submit typical track layout for passenger terminal of medium size, both dead-end and through, and analyze graphically the train capacity of the layout, conferring with Committee on Signals and Interlocking.

(4) Make concise recommendations for next year's work.

(1) REVISION OF MANUAL.

The first subject assigned has been given careful study by your Committee, and a few changes that appear to be desirable are presented for your consideration.

DEFINITIONS FOR YARDS AND TERMINALS.

Transfer Slip.—A protected landing place for transfer boats with adjustable apron or bridge for connecting the tracks on the land with those on the transfer boats.

Incline.—An inclined track (or tracks) at a protected landing place, with adjustable apron and cable for connecting to the tracks on a transfer boat.

Export Pier.—An open or covered pier at which freight is unloaded and stored, mainly for shipment on ocean or coasting vessels.

Station Pier.—A pier having no rail connections where freight is received and delivered by transfer boats.

PRINCIPLES OF PRACTICE.

Lead Tracks.—To facilitate train movements the connections of these tracks with the main track should be interlocked, and to facilitate and protect train movements means of direct communication should be established.

Caboose Tracks.—Where conditions permit, caboose tracks should be so located that cabooses can be placed on, and removed from them in the order of their arrival, and should be so constructed that cabooses can be dropped by gravity onto the rear of departing trains.

Coach Cleaning Yard.—The coach cleaning yard should be conveniently located near the terminal station; the tracks should be of sufficient length to hold full trains, with a car cleaners' repair and supply building adjacent thereto.

Outbound Freight House.—The outbound freight house should be narrow (25 feet is a good average width) and not more than four tracks should be provided. The side toward the tracks should have a platform, and should be fitted with doors moving vertically between the posts.

Where a great number of cars are required, the average trucking distance will generally be least and trucking through cars will be avoided if the freight house is built at right angles to and at the back ends of a series of tracks built in pairs with covered platforms between.

(2) THE MECHANICAL HANDLING OF FREIGHT.

In regard to the second subject, there is little to report. Such developments as have been made relate almost exclusively to the handling of cargo at steamship piers in ocean and inland ports. Nothing appears to have been done in the application of mechanical apparatus to ordinary freighthouse work. The cost of freight handling at terminals, however, is entirely out of proportion to the low cost of transportation in modern railway service, and there are possibilities of considerably reducing this terminal cost by the introduction of mechanical appliances.

Some notes on the development of freight handling at steamship piers are given in Appendix A. In this connection it is to be noted that if freight transportation on inland waterways is developed, suitable methods for handling freight and transferring it between boats and cars or warehouses will be essential for the efficient and economical operation of traffic on such waterways. The plant of the Illinois Central Railroad at Memphis (noted in Appendix A) is of special interest on this account.

The question of the arrangement of tracks at steamship piers has some relation to this matter, and we give in Appendix B an account of some experiments with track arrangements made by the Panama Railroad. This supplements also our former reports in regard to freight terminals.

The handling of baggage and mail sacks by mechanical means is included in the appendix also, as having a relation to the matter of passenger station design which is included in this report.

(3) THE DESIGN OF PASSENGER TERMINALS OF MEDIUM SIZE.

The third subject has been treated as a continuation or supplement to our report on the subject of passenger terminals in our Tenth Annual Report. We submit typical track layouts for both dead-end and through stations that we believe to be susceptible (in their main features) of quite general application.

The information collected as to the principal characteristics of construction and operation of the 26 stations referred to in our report of last year has been summarized and tabulated, and is submitted herewith as information (Appendix C). In the design and construction of terminal facilities the object should be to provide such arrangement of tracks as will permit the greatest freedom of movement with the least interference, to the end that incoming and outgoing trains may be handled without serious interruption or delay. In this way will be secured the maximum efficiency of tracks and facilities and the minimum expenditure for installation.

In the operation of terminal stations many, and in some cases most, of the trains handled have to be hauled out of the station after they are unloaded, and placed in a car-cleaning yard. Unless the facilities are ample, they must be moved again after cleaning, and placed on storage tracks. From the storage tracks they are shifted in proper order and placed on a track in the station for outward movement.

If it is necessary at any time to provide for trains arriving or departing (or both) in rapid succession it is very important that the track layout be so arranged that the inbound and the outbound movements will not conflict to any great extent. This will make it possible not only to permit trains in many cases to enter stations at the same time that other trains are departing, but also to fill vacant tracks in the least possible time after outgoing trains have left them. This, in turn, will secure maximum efficiency and will reduce to a minimum the number of tracks in a station to properly handle the business.

The train capacity of tracks depends largely on the facilities provided for rapid handling of the baggage and express matter that is loaded and unloaded while trains are standing at station platform. It follows, therefore, that in order to handle the largest number of heavy trains within a given time these facilities must be the best that conditions will permit, and, if possible, such arrangements should be made as will eliminate interference with the movement of passengers. To this end it is suggested that where it is possible to do so, baggage and express should be received, delivered and handled below the train floor and raised and lowered by elevators located near the baggage and express cars. This will avoid trucking long distances on platforms used by passengers, to the great discomfort of all concerned and the loss of much valuable time.

There is a very wide variation in the time required to load and unload passengers, baggage and express at stations, depending largely on the character and volume of the business handled by different trains and the facilities provided to insure rapid movement. As a rule the passengers can be loaded on long-distance trains in much less time than is required to handle the baggage and express, but with the short distance and suburban trains (on account of the comparatively small amount of baggage and express to be handled) the conditions may be reversed. In any case it is evident that to secure the greatest efficiency in handling a passenger terminal the time required to load passengers and ordinary baggage and do necessary shifting must be considered as the time interval between the departure of trains on any tracks. Therefore, the express, theatrical and other extra heavy baggage should be loaded prior to making up and placing such trains at the passenger platforms.

The operating officers in charge of the large number of stations covered by our investigations place widely divergent estimates of maximum capacity of station tracks. These estimates range from 2 to 12 trains that could be handled on one track, with an average of about 6.5 trains per hour. These figures no doubt represent a very close approximation to the very best results that could be accomplished for a period of time not exceeding one hour and only after preparation had been made, and therefore do not indicate results that could be expected if a continuous performance were required. At the same stations we find that the actual performance is from 2 to 8 trains, with an average of 4.1 trains handled on one track during the busiest hour. It follows, therefore, that under average existing conditions the actual performance during busiest hours is approximately 4 trains per hour on busiest tracks and that a maximum average of 6.5 trains per hour could be accomplished on some tracks. It is to be noted, however, that the stations at which high estimates of efficiency are made either have through tracks or do a large suburban business with light trains.

If, however, facilities can be provided that will permit continuous and rapid handling of baggage and express without interference with the movements of passengers, it is believed that results approximating the best estimates can be maintained for much longer periods of time, and that the average of 6.5 trains per hour is well within the limit of efficiency that can be secured. But to do this it is conceded that the station, the track layout and all facilities must be designed in harmony and with the principal object of saving time in handling, and thereby securing results that would ordinarily require a larger installation. With this object in view, we have considered the subject of track layouts at terminal passenger stations, both dead-end and through, and present for your consideration diagrams showing typical layouts embodying and illustrating the suggestions submitted. (Figs. 1 and 2.)

In our report of last year, published in Vol. 11 of our Proceedings, at pp. 1283 to 1308, inclusive, we presented a compilation showing the general characteristics of 26 passenger terminals of medium size located in cities in this country. We have now secured additional information as to results obtained in operation, and also estimates as to possible efficiency. We present herewith, in tabulated form, all the information obtained. From this it appears that a number of stations at important points are now working close to the limit of their capacity and are showing very creditable efficiency as to operation. But as they are being worked beyond the limit for which they were designed, it is reasonable to suppose that the cost of operation is excessive and that, therefore, some rearrangements and improvements would be advantageous, to save time and reduce cost of handling.

In the diagram representing a dead-end station with eight platform tracks, the double-track arrangement at the entrance is preserved to the greatest possible extent, so that the use of station or platform tracks may be made practically continuous. Results are thereby secured closely approximate to the best that could be secured in a station with through tracks and the same length of platforms. It is suggested that where large numbers of passengers arrive in quick succession (as in the case of suburban traffic), full consideration should be given to the question of providing the passages for egress with inclined floors instead of stairs, with the object of increasing capacity and preventing congestion. It is recommended that the grade or fall of such sloping floors be not greater than one in ten (or 10 per cent.), and that all such floors be kept rough at all times, so that slipping may be avoided.

At stations of either type the time required to place a train on a station track, load it, and clear the track for another train is the minimum time interval between departures of trains from any one track. Therefore, to secure maximum efficiency the track layout must permit operation practically without interference, as in stations with through tracks, and baggage and express handling must not retard the movement of trains beyond the time needed to properly handle the passengers.

It should be understood that the accompanying plans represent generally desirable and advantageous arrangements of tracks, but that they are not submitted as standard plans. While there are many accessory features which are shown and which might be discussed, their arrangement is merely suggested as incidental to the general plan, since in most cases this arrangement will be governed largely by local conditions and circumstances. The principal feature of the plans is the station layout, with its tracks and track connections.

In regard to the dead-end terminal plan, the Committee desires to explain that the only feature upon which stress is laid is the provision made at the ends of the station or platform tracks to promote rapid handling of trains and to avoid interference between the inbound and outbound trains. This feature can be applied much more extensively than has been attempted as yet. The other matters (such, for instance, as turntable and coach yard location, with their track connections) are incidental. Their arrangement in the general plan must in almost any case be made to fit local conditions. Therefore, these features of the plans submitted are not considered as matter for criticism in relation to this report, but only as being complementary to the station plan.

It is believed that the track arrangement shown is exceptionally well adapted for the handling of a large number of trains in and out of eight platform tracks at minimum cost and in a minimum time. This feature is independent of the incidental features mentioned above.

In regard to the track layout for a through station, it will be noted that the location is shown at a junction of two double-track roads. A separate station platform is provided for the movement in each direction. All trains making the station stop must be switched from the main track to one side or the other of one of these platforms, thus clearing the main line while the stop is being made. In some station plans a middle platform separates the two pairs of tracks, but it is the opinion of the Committee that it is unnecessary to switch trains across one of the through tracks (as with a three-platform plan). Therefore, the double station or double platform plan was adopted, the two main tracks being continuous and on their proper line through the station.

It will be noted also that a station of this kind has almost unlimited capacity, and, therefore, there is comparatively little necessity for much additional trackage. The platforms being of ample size, four ordinary trains can stand at the platform at one time. As these platforms are approached from the bottom, and the baggage and express are handled by elevators, there would be very little interference and the station would be found to have very great capacity.

CONCLUSIONS.

*(1) To avoid excessive cost in providing passenger terminal facilities largely in excess of ordinary requirements, it is imperative that provision be made for economical, efficient and practically continuous operation of the terminal during the periods of greatest activity which may reasonably be expected within a period of, say, ten years. To this end, the track layout must be designed to permit incoming and outgoing movements to be made at the same time, without interference, as far as it is possible to arrange this.

*(2) At passenger terminals where large quantities of baggage and express must be handled, and it does not appear desirable or expedient to provide intermediate platforms to be used exclusively for this service, it is recommended that (where conditions permit) baggage and express be received, delivered and handled below the train floor, and raised and lowered by elevators, conveniently located, to avoid interference with the movement of passengers.

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*See amendments, page 242.

FIG. 1.

TRACK LAYOUT AT PASSENGER TERMINAL STATION.

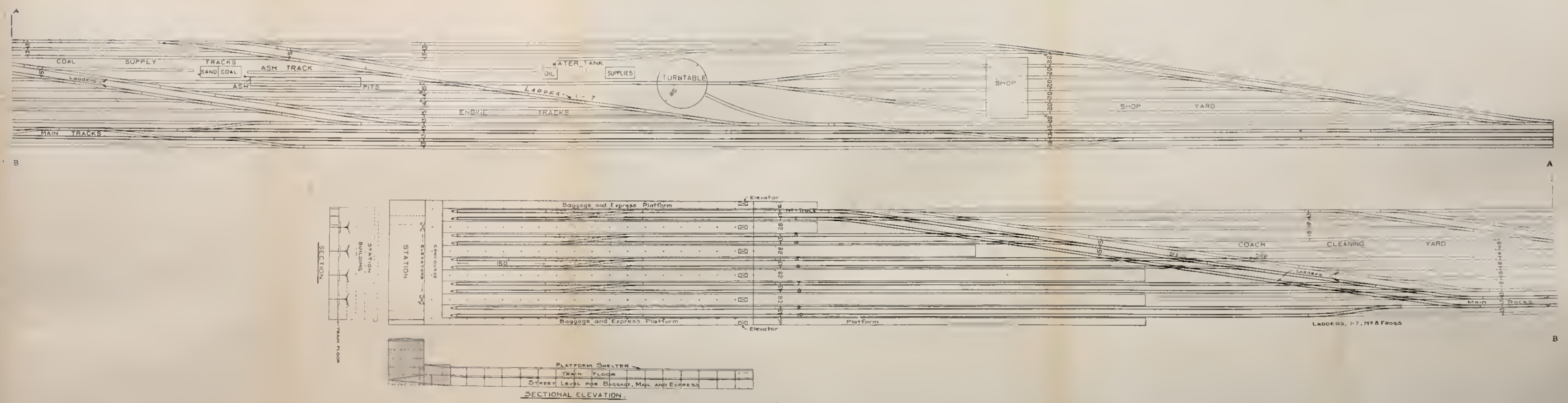
A
COAL SUPPLY TRACKS
SAND
COAL
ASH TRACK
ASH PITS
Ladders
WATER TANK
OIL
SUPPLIES
TURNTABLE
LADDER 1-7
ENGINE TRACKS
MAIN TRACKS
SHOP
SHOP YARD
B
A
Baggage and Express Platform
Elevator
SECTION
STATION BUILDING
STATION
ELEVATORS
CONCOURSE
150
COACH CLEANING YARD
Ladders
Main Tracks
Platform
LADDERS, 1-7, No 8 FROGS
B
TRAIN FLOOR
PLATFORM SHELTER
TRAIN FLOOR
STREET LEVEL FOR BAGGAGE, MAIL AND EXPRESS
SECTIONAL ELEVATION.

Fig. 1

FIG. 2.

Layout at Passenger Terminal Station.

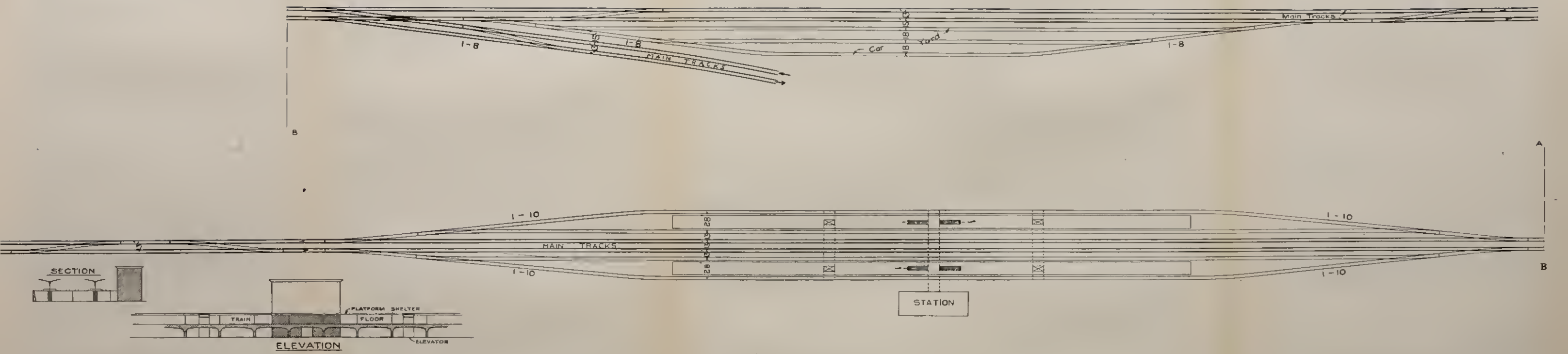
Main Tracks
1-8
1-8
1-8
MAIN TRACKS
Car Yard
B
A
B
1-10
1-10
1-10
1-10
MAIN TRACKS
STATION
SECTION
PLATFORM SHELTER
TRAIN
FLOOR
ELEVATOR
ELEVATION

Fig. 2

FREIGHT YARDS FOR INTERCHANGE TRAFFIC.

While the work assigned for this year related entirely to passenger terminals, we give in Appendix D a part of a report of exceptional interest in regard to the handling of interchange traffic at a point where numerous railways have their own individual yards. This condition exists at Chicago, and with the enormous amount of traffic to be handled, the present system causes continual congestion and confusion. It was to relieve this condition, by providing an interchange yard for the joint use of the railways, that the extensive yard at Clearing (Chicago) was established by an independent company. As yet, however, no use has been made of this facility for its intended purpose. The yard was described in our report for 1906. With such a yard in general use, through cars need not enter the city yards or individual yards, and the long haul on belt lines from yard to yard would be avoided.* Under the present system the congestion has grown steadily worse. The Terminal Official Association of Chicago appointed a special committee to investigate and report upon the general betterment of yard conditions in the Chicago terminals. Its report recommends that outside terminal yards supplement the local facilities and that there should be a separation of through and local interchange business in order to relieve the congestion in the local yards. It shows also that several railways and belt lines are providing additional engines and additional yard facilities which should materially help the situation, but it appears evident from the report that some more radical step is needed than the improvement of individual facilities.

Respectfully submitted,

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*The present and proposed system of handling through and interchange freight at Chicago was described in detail in the "Engineering News" of January 2, 1902.

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A. SWARTZ, Division Engineer, Erie Railroad, Huntington, Ind.
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Committee.

AMENDMENTS.

Amend conclusion (1) to read as follows:

"(1) To avoid excessive cost in providing passenger terminal facilities largely in excess of ordinary requirements, it is imperative that provision be made for economical, efficient and practically continuous operation of the terminal during the periods of greatest activity, which may reasonably be expected within a period of, say, twenty years. To this end, the track layout may be designed to permit incoming and outgoing movements to be made at the same time, without interference, as far as possible to arrange this."

Amend conclusion 2 to read as follows:

"(2) At passenger terminals where large quantities of baggage and express must be handled, and it does not appear expedient to provide intermediate platforms to be used exclusively for this service, it is recommended that (where conditions permit) baggage and express be received, delivered and handled below the train floor, and raised and lowered by elevators, conveniently located, to avoid interference with the movement of passengers."

Appendix A.

MECHANICAL HANDLING OF FREIGHT.

River and Rail Freight Terminal: Illinois Central Railroad.—During the year the Illinois. Central Railroad has built at Memphis a freight-handling telferage system of special interest, this being used for transferring freight (largely cotton bales and lumber) from Mississippi River steamers to railway cars. The river has a range of about 30 ft. in its water level, and at extreme high water the ground where the new terminal is built is submerged. To enable the terminal to be operated at any stage of the river, an embankment extending above the highest water level is built out from the high ground to the edge of the river bank. On this embankment is a freight platform 30 ft. wide and 300 ft. long, with a track on each side. Along the middle of the platform is built a narrow trestle composed of two-post bents (with inclined posts and short caps). At the river end of the trestle is a four-post steel tower carrying a 90-ft. truss which has a cantilever projection of 60 ft. over the river. The tower posts are anchored to a concrete foundation block supported on piles.

Attached to the bottom of the caps of the trestle and the floor beams of the steel span is a line of 20-in. 60-lb. I-beams. On each side of the bottom flange of the I-beam are cast-iron saddles (bolted against the web) which carry light steel T rails. These rails form the runway for the traveling trolley hoist. This arrangement of runway was adopted because it has been found that where trolleys ride directly on the I-beam flanges, these flanges gradually bend downward. The traveling trolley has two four-wheel 5-ton electric hoists 16 ft. apart, and beneath it is a carriage for the operator. The hoisting speed is 60 ft. per minute, and the traveling speed 600 ft. per minute. Electric current (200 volts) is taken from an overhead wire carried beneath the caps of the trestle.

A large amount of the freight handled consists of cotton bales, and special low trucks are used for these, each truck holding five bales. These trucks are raised and moved by the traveling trolley, in the same way as the freight trucks at the old Dominion Steamship Company pier, described in our report of 1908. The trucks are landed on the platform and wheeled directly to the cars. Logs, timbers, etc., can be carried beyond the platform and loaded directly into flat or open cars on a stub track between the two platform tracks. This telferage system is shown in Figs. 3 to 7.

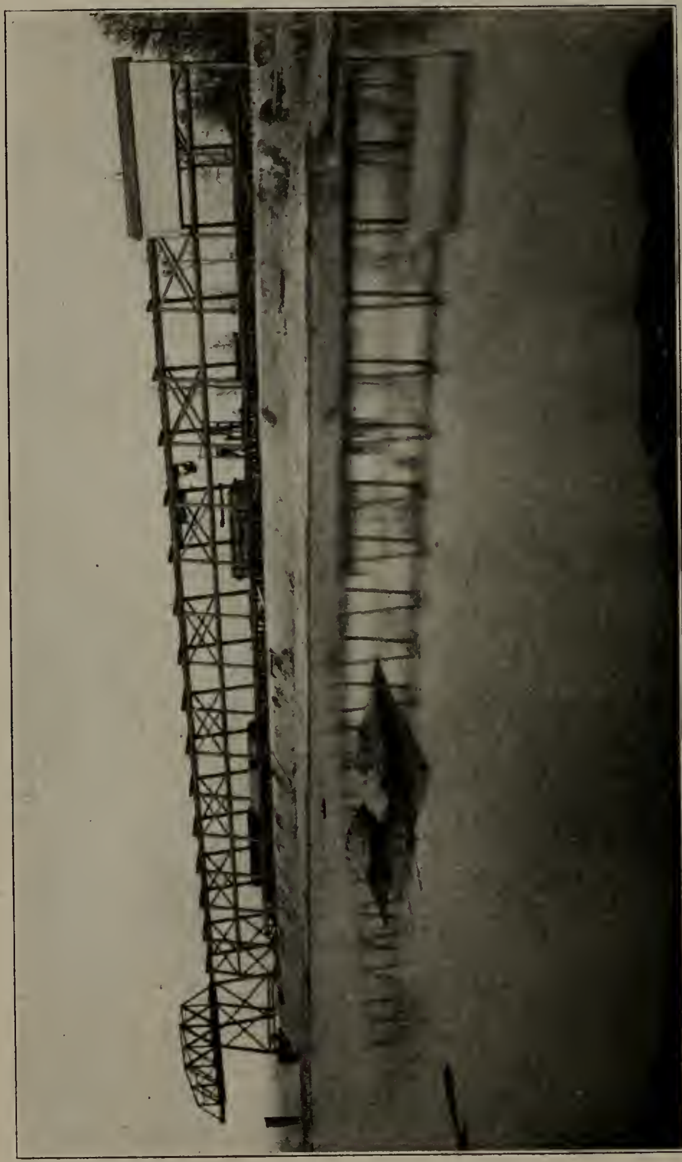

Fig. 3.

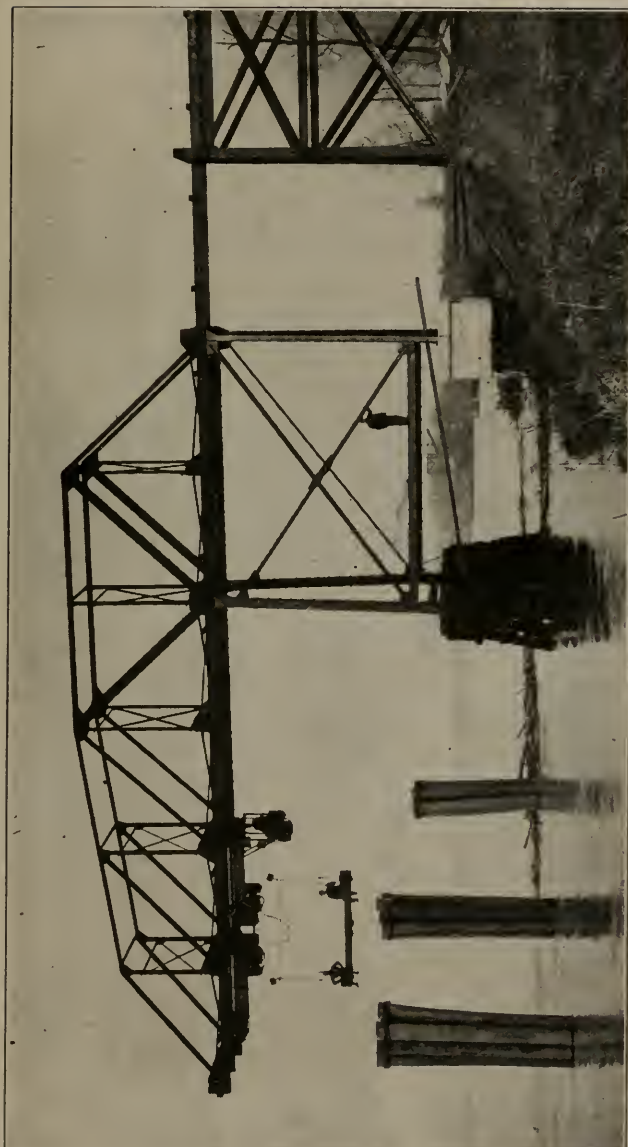

Fig. 4.

Freight Conveyors for Steamship Piers.—The Pacific Coast Steamship Company has at Pier D, in Seattle, an endless traveling ramp or platform for loaded freight trucks. At the Galbraith pier, also, there is placed close under the roof a conveyor for handling bales of hay; this has a capacity of 400 bales per day.

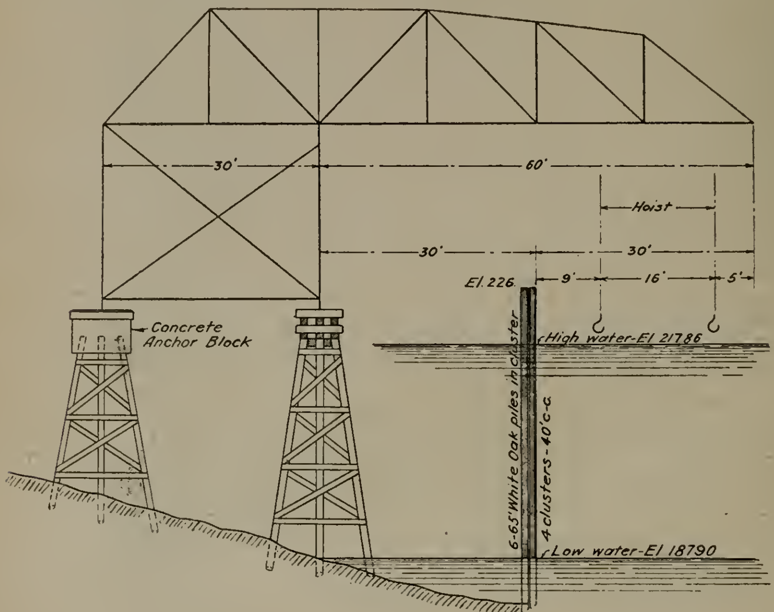

FIG. 5.

At Seattle, also, traveling platform conveyors have been installed for transferring ship's cargo between the pier sheds and warehouses. The land end of the pier is separated from the warehouse by a street and railway tracks, so that trucking is very inconvenient. The conveyors, therefore, travel on timber truss bridges, which are covered in order to protect the packages from damage. The conveyors handle barrels, cases, hay bales and miscellaneous packages. The platform is 3 ft. wide, and consists of transverse planks bolted to a pair of chains, which pass over 3-ft. sprocket wheels at each end of the conveyor; at one end the sprocket wheel is geared to a 10-HP. electric motor. Cleats are placed at intervals of 3 ft. to hold barrels, etc., in place. At the pier the conveyor rises through the floor (so that it is easily loaded) and then on an incline of 25 degrees to the bridge crossing the street. When handling cement barrels (400 lbs.), these are unloaded at the pier by the steamer's cargo booms, each load consisting of six barrels in a sling. They are landed near the conveyor and rolled directly upon it. With the intermittent supply, the conveyor handles about 360 to 400 barrels per hour, but with a steady supply it can handle from 1,000 to 1,200 packages an hour.

The Reno inclined elevator is a narrow traveling platform, composed of rows of parallel bars in short lengths, on the same general plan as the moving stairways now in use in department stores, etc. This elevator is placed on fixed inclines between the floors. The side bars of the elevator may have lugs at intervals to engage with the axles of the trucks. Machines 60 to 80 ft. long have been installed in a hay warehouse and in department stores. Another device of the Reno company is a sprocket chain which forms a continuous traveling rack, the teeth of which engage with the axles of the trucks. This is placed on the adjustable inclined platform or ramps used at steamship piers, and in this case the men walk up the incline instead

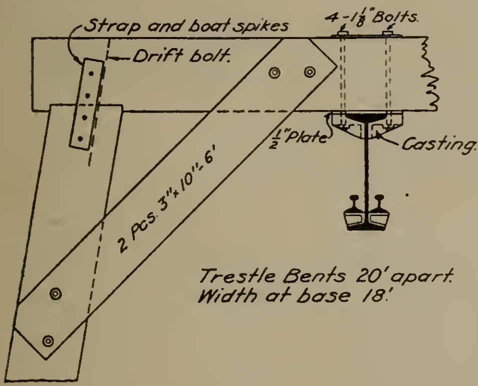

Fig. 6.

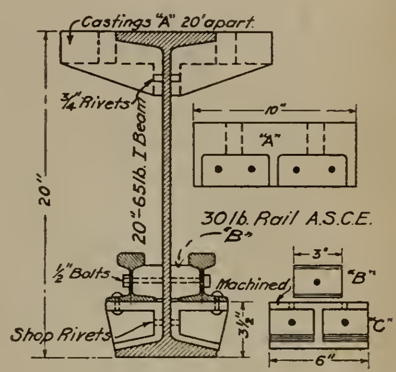

Fig. 7.

of riding on a traveling platform. The chain may be lowered beneath the level of the floor of the ramps. Several of these have been installed. The chain runs at a speed of 100 ft. per minute and is driven by a 5 HP. motor. In a modified design proposed for use in freight houses (on the level floor), there is an endless chain beneath the floor having lugs forming a rack upon one side. This rack is under a slot in the floor and each truck has a hinged tongue which may be dropped into the slot to engage with the chain. A very similar arrangement was described in our report of 1909, but no plants of this kind have been installed.

Freight Handling Derrick.—Nearly every large freight yard has a fixed derrick, a crane, a traveling crane, a gantry or other mechanical device for transferring heavy and bulky freight between cars and wagons. The Minneapolis, St. Paul & Sault Ste. Marie Railway has installed at Minneapolis an unusually large stiff-leg electric derrick for work of this kind. It has a mast 40 ft. high and a boom 30 ft. long, with a working radius of from 10 ft. to 30 ft. The two stiff legs are nearly horizontal, their outer ends being supported by A-frames. This arrangement enables the boom to swing through an entire circle even at its maximum reach. The hoisting capacity is 15 tons. All the members are of steel, and the mast and A-frames stand on concrete pedestals. All the machinery is mounted on the mast, under direct control of the operator.

The electric current is led up through the foundation and the pivot of the mast to contact rings, from which it passes directly to the 22 HP. variable speed motor. The motor is geared directly to a double-drum hoist, one drum for the hoisting cable and the other for raising and lowering the boom. The swinging is done by gearing which engages an 8-ft. circular rack. To provide against failure of current a 15-ton double-drum hand-hoist is mounted on the mast, but of course the cables would have to be transferred from the drum of the power hoist to those of the hand-hoist.

Motor Trucks for Handling Baggage.—The handling of great quantities of baggage is one of the troublesome problems in operating large stations. Reliance is still placed almost universally in manual labor and man-power trucks. Conveyors have been used abroad to a small extent, and it is believed with successful results. The Pennsylvania Railroad has made a start in the introduction of motor trucks, and has a number of these in use at its terminal stations at New York, Jersey City and Washington. In this way the baggagemen are relieved of the hard work of hauling heavily loaded trucks over long distances. The baggageman also rides on his truck, so that greater speed is obtainable even with heavier loads. This expedites the work to such an extent that it has been found possible for the regular staff to handle all the baggage at holiday rush seasons, etc., without the necessity of employing inexperienced men as helpers, who often cause additional troubles from their lack of experience.

The trucks are of the storage battery type, weighing about 2,400 lbs. and having a load capacity of 4,000 lbs. For stations having low platforms, the floor of the truck is above the wheels and practically level with the car floors. For stations having high platforms, the floor of the truck is dropped between the axles and is only a few inches above the platform. The motor is geared to the rim of the wheel and there is a controller at each end of the truck. With one controller in use, the other is automatically made inoperative. There are three speeds (for either direction) : two, four, and six miles per hour. When the driver steps off the platform on which he rides, the brakes are applied and current is cut off automatically.

The Hudson & Manhattan Railway, which operates an underground electric railway connecting several of the large passenger terminal stations at New York (or both sides of the Hudson River), has special flat cars for transferring baggage trucks between the stations. This saves much time otherwise consumed in loading, unloading and hauling transfer baggage. The cars are of steel, with low sides formed by hinged panels which can be lowered to form aprons bridging the space between the car and the platform, thus allowing the trucks to be wheeled on and off the car with ease.

Mail Conveyors.—The new Chicago terminal station of the Chicago &

Northwestern Ry. will have conveyors for handling the mail sacks from inbound trains. These will be placed between the tracks of four pairs of station tracks. They will consist of endless belts, level with the floor and extending to the branch postoffice which is located on the lower or street floor of the station.

Appendix B.

THE ARRANGEMENT OF LOADING TRACKS AT PIERS.*

The study of a track layout most suitable for serving the proposed new dock of the Panama Railroad at Cristobal, the Atlantic terminus of the Panama Canal, showed that the position of loading tracks can affect the cost of handling freight between ships and cars about 20 per cent. The cargo to be handled here is package freight, i. e., general merchandise in boxes and packages, which is unloaded from the ship by tackle or skids and then wheeled into cars by means of the ordinary hand-trucks. Special docks with handling plant and cantilever crane are reserved for coal, ties, rail and piles, and solid shiploads of supplies such as dynamite and cement.

The proper position of loading tracks is at an angle to the ship and not parallel to it, as is customary. Dock No. 4 of the Panama Railroad at Cristobal, Canal Zone, as shown in Fig 8, illustrates both positions. When a ship is at the side toward the open sea marked "Angle Berth," the loading tracks are at an angle of about 60 degrees with the ship, but when a vessel is in the slip between docks No. 3 and No. 4, marked "Parallel Berth," then these same tracks lie parallel to the ship. The relative merits of both types of tracks under the same conditions have been compared here.

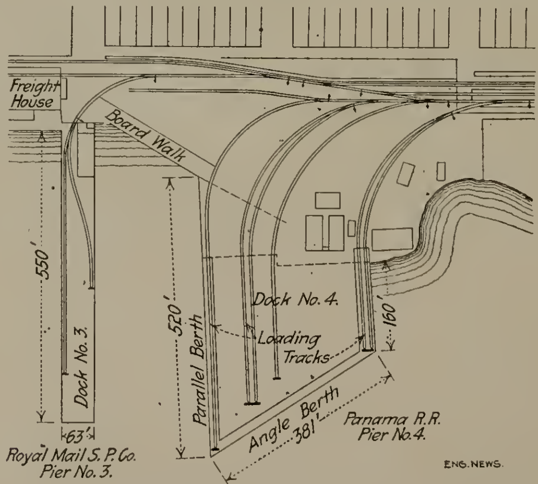

Fig. 8. Panama R. R. Dock No. 4, Cristobal, Canal Zone, Panama.

(Arranged for testing comparative efficiency of parallel and angular loading tracks.)

*A paper by Mr. E. B. Karnopp, Assistant Engineer of the Panama Railway, in "Engineering News," September 29, 1910.

The accompanying table shows data collected by one of the steamship companies, giving the cost per ton for "stevedoring" for a period of three months. Stevedoring means, in this case, transferring the cargo from the ship's hold onto the dock floor. The packages are assembled into rope slings, hoisted by the ship's tackle and deposited on the floor in complete consignments, after which the railroad company does the "handling," that is, transfers the cargo from the ship's side to the cars.

COST OF STEVEDORING AT CRISTOBAL DOCK OF PANAMA RAILROAD.

Ships at Angle Berth	Ships at Parallel Berth
3,700 tons @ 11½ cts........$425.50	900 tons @ 20 cts..........$180.00
4,950 " " 12¾ cts........ 631.12	780 " " 18 cts.......... 140.40
3,400 " " 17½ cts........ 595.00	900 " " 17½ cts........ 157.50
950 " " 18¾ cts........ 178.13	700 " " 19¼ cts........ 134.75
950 " " 15¼ cts........ 144.88	1,170 " " 17 cts.......... 198.90
1,200 " " 13½ cts........ 162.00	940 " " 18 cts.......... 169.20
4,650 " " 16¼ cts........ 755.63	655 " " 25 cts.......... 163.75
	800 " " 20 cts.......... 160.00
	1,000 " " 12 cts.......... 120.00
	800 " " 20 cts.......... 160.00
	730 " " 16 cts.......... 116.80
19,800 tons @ 14.6 cts......$2,892.26	9,375 tons @ 18.1 cts.......$1,701.30

The figures in the table show for this one company's business a reduction in cost of 3.5 cents per ton, or 18.9 per cent in favor of the angle tracks, and although the average cargo per ship while at the angle berth happened to be three times that of the parallel berth, yet these figures represent typical conditions.

The same relative economy holds true for the railroad's "handling." It has been observed that an amount of cargo requiring, at the parallel berth, about four days to be transferred to cars, can be cleared away in about three days when at the angle berth.

The angle tracks have several advantages not possessed by the other arrangement. When freight is stored on the dock floor, as may happen from shortage of cars or labor, it can be scattered over a great area where it becomes more accessible and does not have to be piled up on a small platform space, which evidently, under the parallel track scheme, would have to be narrow to make the trucking distance between the ship and cars as short as possible. It is a fact that it is much cheaper to truck freight several hundred feet than to pile it up in stacks. Another advantage is that any track can be switched without interfering with the others and there need be no long line of filled cars waiting for a few to be completed.

Inbound and outbound freight can be worked at the same time, which is not feasible with the parallel arrangement. The cars on the second parallel track can only be loaded by trucking through the cars on the track nearest the ship, but every car on an angle track can be loaded without interfering with another.

Fig 9 shows the plan of the proposed Dock No. 12 as adopted. The tracks are in pairs at an angle of 45° with the ship, but would have been made 90° if more ground space were available. All the tracks are depressed so that the floor of the dock is flush with the cars. The southern end of Dock No. 11 is also shown at the left in Fig. 2. It has been in operation several years with two parallel loading tracks. The width of floor and roof is 110 ft. from face line to the back wall. The width of the proposed dock is 207½ ft.

The angle arrangement of loading tracks requires greater area of ground, superstructure and floor, but its installation is to be recommended when the saving in operation will more than offset the additional cost of construction.

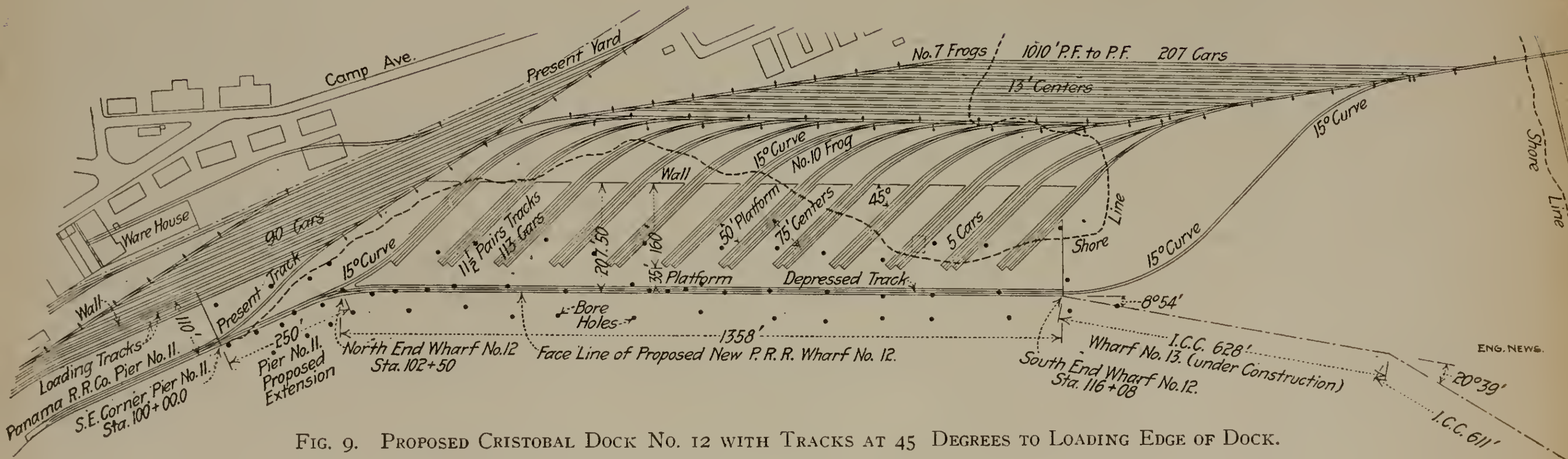

FIG. 9. PROPOSED CRISTOBAL DOCK NO. 12 WITH TRACKS AT 45 DEGREES TO LOADING EDGE OF DOCK.

Appendix C.

FACILITIES AND TRAFFIC AT PASSENGER TERMINALS.

SUMMARY OF TERMINAL DATA.

	STATION.	LOCATION.	TYPE: Through.	TYPE: Headhouse.	TYPE: Over Tracks.	STATION BLD'G.: At End of Tracks.	STATION BLD'G.: Side of Tracks.	GRADE OF TRACKS.: At Streets.	GRADE OF TRACKS.: Over Streets.	GRADE OF TRACKS.: Under Streets.	Through Trains Daily.	Trains Originating.	Trains Terminating.	No. of Trains Handled During Busiest Hour.	No. of Trains Handled on One Track During Busiest Hour.	Est. No. of Trains that Could Be Handled During Busiest Hour.	Est. No. of Trains that Could Be Handled on One Track During Busiest Hour.	Number and Spacing of Tracks.	Number and Width of Platforms.	Length of Platforms.	Height Above Top of Rail.	Are Tracks on Tangent or Curve.	Are Switches Interlocked.
1	Dearborn	Chicago, Ill.		*		*		*			0	53	55	14	3	17	3	10 (see Plan)	See Plan	670′	6"	Tangent	No.
2	D. L. & W.	Hoboken, N. J.		*		*		*			0	127	118	29	5	54	8	14-13′0" C.-C.	8-20′; 1-17′	700′	6"	Tangent	Yes
3	Erie	JerseyCity, N. J.		*		*		*			0	123	126	28	8	33	12	10-15′0" C.-C.	5-15′	650′-700′	2"	Tangent	Yes
4	Long Isl'd.	Long Island, N.Y		*		*		*			0	135	134	60	5	65	12	24-24′-0" C.-C.	9-14′	760′	9"	Tangent	Yes
5	Union	New Orleans, La.		*		*		*			0	11	11	6	2	12	3	4-24′-0" C.-C.	2-17′	704′	7"	Tangent	Yes
6	Union	Cincinnati, O.		*		*				*	0	69	67	28	4	30	5	8	4-13′ & 15′	1-600′; 3-650′	10"	Tangent	No.
7	Union	Louisville, Ky.		*		*		*			6	24	24	14	3	32	12	6-26′&20′C.-C.	3-17′; 2-11′	450′-600′	6"	Tangent	No.
8	Union	Savannah, Ga.		*		*			*		10	8	8					9-14′to25iC-C.	4-15′; 3-10′	600′	7"	Tangent	Yes
9	Union	Columbus, Ohio.	*				*			*	25	34	35	19	4	19	5	8-11′-0" C.-C.	1-11′; 3-17′	2-678′; 2-774′	8"	Tangent	No.
10	B. & O.	Philadelphia. Pa.	*				*			*	20	14	14	6	3	12	4	6-12′&13′C.-C	2-23′; 1-12′	700′	0"	Tangent	Yes
11	B. & O.	Baltimore, Md.	*				*			*	26	12	6	8	6	12	6	5-12′ C.-C.	Shed Area	426′	0"	Tangent	Yes
12	B. & O.	Baltimore, Md.	*	*		*	*	*		*	37	20	25	6	2	12	3	7-12′&50′C.-C.	3-15′	610′	15"	Tangent	Yes
13	Union	Peoria, Ill.	*				*	*			0	43	39	14	4	78	12	7	1-18′;3-12′;1-6′.	480′	0"	Tangent	No.
14	Union.	Troy, N. Y.	*				*	*			57	24	20	14	7	25	10	7-12′ C.-C.	4-12′	3-400′; 1-310′	10"	Tangent	Yes
15	Union	Albany, N. Y.	*				*				88	35	34	17	6	17	6	8	3-28′; 1-27′	650′-850′	6"	Tangent	Yes
16	P. & R. Ry	Reading, Pa.	*				*		*		32	14	14	12	3	30	5		1-20′; 2-15′	1100′	8"	Tangent	Yes
17	Penna. R.R.	Harrisburg, Pa.	*				*		*	*	55	47	45	8	5	30	6	8-12′ C.-C.	5-37′-22′	765′-860′	7"	Tangent	Yes
18	Union	Birmingham, Ala.	*				*	*			6	20	20					10-12′ C.-C.	5-19½′	3-620′; 2-770′	8"	Tangent	Yes
19	C.M.& St.P	Milwaukee, Wis.	*				*				22	30	32	12	3	20	6	5-13′&20′C.-C.	Shed Aren	1000′—Max.	0"	Tangent	No.
20	Union	Minneapolis, Minn.	*				*			*	44	30	30	16	2	30	2	6-26′ C.-C.	Shed Area	1200′	0"	Tangent	No.
21	Union	Indianapolis, Ind.	*				*	*			46	42	40	30	4	37	5	8	Shed Area		0"	Tangent	
22	Union	Toledo, Ohio	*	*			*			*	43	39	40					13-12′ C.-C.	3-26′		0"	Tangent & Curve.	No.
23	Union	Nashville, Tenn.	*	*	*					*	10	26	26	11	2	15	4	10-20′&28′C-C	5-20′. 4-11′	550′-750′	9½"	Tangent	Yes
24	Union	Richmond, Va.	*	*		*	*		*		10	7	7					9-12′; 23′&13′.	2-8′; 5-14½′	650′-1248′		Tangent	Yes
25	Union	St. Paul, Minn.	*	*		*	*	*			92	46	46	42	5	42	5	14-26′&13′C-C	8-16′	800′	12"	Tangent	No.
26	Union	Seattle, Wash.	*	*		*	*			*	6	35	36					11-12′ C.-C.	4-18′	200′	0"	Tangent	No

SUMMARY OF TERMINAL DATA.—Continued.

	STATION.	LOCATION.	Method of Making Up and Breaking Up of Trains.	Are Engines Changed on Through Trains.	Are Cars Added or Dropped, and Why.	Special Arrangements For Handling Suburban Traffic.	Method of Handling Express and Baggage.	System of Communication From Dispatcher To Train Conductor.	Distance To Engine House.	Distance To Car Storage Yard.	If Union Station. What Is System of Handling
1	Dearborn	Chicago, Ill	Switch Engines	No.		None	Trucks	None	5m	5.6m	Own'g Co. handles
2	D. L. & W	Hoboken, N. J	Sw.Eng.&Gravit	No.		None	Trucks & Cars	Thru Sta. Master	1800′	600′	Not.
3	Erie	Jersey City, N. J	Sw. &Road Engs	No.		None	Trucks	Semaphores	800′	700′-4500′.	Not.
4	Long Island	Long Island, N. Y.	Sw.&RoadEng's.	No.		None	Sw.Eng.&Trucks	Thru Sta. Master	¼m	¼m	Not.
5	Union	New Orleans, La		No.		None		Thru DispatchOff.			Not.
6	Union	Cincinnati, Ohio		No.			Trucks	Telegraph			Sep. sta. empl'ees.
7	Union	Louisville, Ky	Switch Engines	Yes	Sleepers&Diners		Truks & Sw.Eng.	Telegraph	1800′	2800′	
8	Union	Savannah, Ga	Switch Engines	Yes	Seldom	None	Trucks & Floats.	Telegraph	2&4m	9300′	
9	Union	Columbus, Ohio	Yard Engines	Yes	As TrafficChange	None	Trucks	Telegraph			
10	B. & O	Philadelphia, Pa	Switch Engines	Yes	Diners	None	Trucks	Station Wire	1m		Not.
11	B. & O	Baltimore, Md	Yard Engines	No.	1 Sleeper to N. Y	None	Trucks	Thru Sta. Master	2500′	2500′	Not.
12	B. & O	Baltimore, Md	Switch Engines	No.	Occasionally	None	Trucks	Sta. Mas. & Tower	3000′	2500′	Not.
13	Union	Peoria, Ill		No.		None		ThruDispatch.Off.	1½m	Adj't	Sep. sta. empl'ees.
14	Union	Troy, N. Y		Yes	No		Trucks	Messenger	1m	1m	Sep. sta. empl'ees.
15	Union	Albany, N. Y		Yes	Yes, Connections		Trucks and Elev.	None	¾m	Adj't	
16	P. & R. Ry	Reading, Pa	Switch Engines	No.	Yes, Connections	None	Trucks & Cars		1m	Adj't	Not.
17	Penna, R. R.	Harrisburg, Pa	Switch Engines	Yes	Yes		Trucks and Elev.	Thru Sta. Master	4150′	650′	Not.
18	Union	Birmingham, Ala	Yard Engines	Yes	Yes, Connections		Trucks and Elev.	Telegraph	¼-1m	¼-1m	Not.
19	C. M. & St.P	Milwaukee, Wis		Yes	Added; LocalSer.		Trucks and Elev.		2m	¼m	
20	Union	Minneapolis, Minn		No.	As Required			Telegraph			
21	Union	Indianapolis, Ind	Yard Engines	Yes	Yes	None	Trucks	Teleg. & Telephone	½ to 1½m	½ to 1½m*	Sep. sta. empl'ees.
22	Union	Toledo, Ohio		Yes	AsTrafficChang		Trucks	ThruDispatch. Off.	Adj't	Adj't	
23	Union	Nashville, Tenn	Switch Engines	Yes	Sleepers & Diners		Trucks	Telegraph	800′	800′	
24	Union	Richmond, Va	Switch Engines	Yes	Yes		Trucks and Elev.	Messenger	⅞-3.7m	½-3.7m	
25	Union	St. Paul, Minn		No.	Yes		Trucks and Elev.	Telegraph	½m	½m	Sep. sta. empl'ees.
26	Union	Seattle, Wash		Yes	As Required		Trucks and Elev.		None	1000′	

* Indianapolis.—Car storage yards ½ to 1½ miles distant; except Pullman yard, 600 feet.

Appendix D.

IMPROVEMENTS FOR THE HANDLING OF INTERCHANGE FREIGHT BUSINESS AT CHICAGO.

The following are recommendations made in a report by a special committee appointed by the Terminal Officials' Association of Chicago, and presented at a meeting of that association in September, 1910:

"Every effort should be made by all lines to provide power enough to keep their Chicago terminals open for the receipt and movement of business. The congestion last winter, undoubtedly, caused a good deal of freight to be moved via other than the Chicago gateway, and this is a condition which should not be, on account of the loss in revenue and the fact that all Chicago lines have spent a great deal of money on their main lines leading to and from Chicago to enable a large traffic to be handled. It is exceedingly regrettable that any of the benefit of this expenditure should be lost by reason of shortage of power to handle the business in and out of Chicago.

"Belt lines should, at all times, keep their lines open for the free movement of business which can be accepted by Trunk lines. When they are not able to make all deliveries promptly to any line they should notify that line and all other lines, advising how many cars they will receive from each Trunk line for the congested line each twenty-four hours, and delivering lines should arrange their deliveries accordingly.

"In the event of lines becoming congested which have large local industry business in Chicago, they should advise all lines whether they are in position to receive local business freely, and, if so, it should be switched out and delivered in preference.

"Much can be done in the way of relieving congestion if delivering lines will acquaint themselves with the conditions on congested lines and do all in their power to help out the situation by making direct deliveries or using alternate Belt lines. The loss of traffic caused by congestion reacts as strongly upon delivering lines as it does upon receiving lines, and it is to their interests to do whatever is necessary to move their traffic. At interchange points, lines which are open should not compel congested lines to resort to the practice of trading trains, and every line which is open should keep its receiving tracks clear at all times. A greater spirit of harmony should prevail in such matters.

"It is our opinion that the suggestions made above, if put into effect, would materially improve interchange conditions as they exist with the present facilities.

"The business handled within the Chicago switching district has increased so much faster than the facilities which have been provided for handling it that a separation between the through business and the local business is becoming imperative.

"The enormous increase in traffic has overtaxed the facilities. While the railroads have added to their facilities, these improvements have not equaled the development of the traffic. In fact, the rapid building up of the city has made it impracticable in many instances for railroads to extend their present terminals. Facilities in the elevated sections of Chicago which were formerly available for freight traffic are now needed urgently to take care of the immensely increased passenger and local freight business.

"The necessity for relieving the downtown facilities of freight traffic is beyond dispute. The question of determining the best means of accomplishing this relief is the purpose of this Committee. Certain of the traffic, such as freighthouse business and carload business for patrons located in the downtown district, must necessarily use these overtaxed terminals and no relief can be looked for from this direction. Relief, therefore, must come from the shifting of the interchange traffic.

"Statistics show that there are now being received in Chicago approximately 4,000,000 loaded cars a year, of which about 775,000 loads is business moving to points beyond Chicago. About an equal amount is interchange business destined to points within Chicago. It is apparent that relief from the crowded conditions in Chicago, not only now but in the future, must be obtained by separating the interchange business moving through Chicago from the interchange business destined to local points within the city.

"It is our judgment that the inside yards of the city can now take care properly of not more than the interchange business destined to Chicago proper, and that such yards should not be burdened with the business moving to points beyond Chicago. We recommend that all lines having interchange freight to deliver, make a separation of through and local business and that they make their deliveries to connecting lines through channels that will keep these two classes of business separate.

"We feel that the interchange facilities around Chicago are sufficient if supplemented by proper outside terminal yards, to handle the business for years to come, but that it will be necessary to use all of the facilities that now exist in order to prevent congestions and delays to freight with their attendant prejudice against the Chicago gateway."

Appendix E.

NOTES ON NEW PASSENGER TERMINALS.

Chicago.—The new passenger terminal station of the Chicago & Northwestern Ry. will have 16 station tracks arranged in pairs (12 ft. c. to c.) except for a single track at each side. There will be eight platforms. The trainshed is of the Bush type, 39 ft. 3 in. span between centers of columns; the columns are in the middle of the platforms, and 25 ft. apart. The height from rail level is 16 ft. 9 in. at the center of the span and 11 ft. at the columns (springing line). Each span has a 36-in. opening over the center of each track, and a skylight over each platform. This trainshed is about 850 ft. long and 320 ft. wide. Four of the pairs of tracks have belt conveyors (between the tracks) to deliver mail sacks from trains to the branch postoffice in the station.

The tracks are on the upper level. The train floor is supported by a row of columns under the center of each track, the columns having brackets for the two plate-girder track stringers, one directly under each rail. The rails are laid on longitudinal timbers on the girder flanges. The floor and platforms are of concrete and asphalt.

Kansas City, Mo.—The construction of the great union station and passenger terminal is now actually under way. The station will be of the through type, with the station building at the side of the tracks. Its present design (with 16 station tracks and two running tracks) is said to provide sufficient capacity for handling 317 trains per day. The preliminary plans showed 18 parallel through tracks, in pairs, with space for six additional tracks, in addition to stub tracks at each end of the station. The offices will be on the street level of the main building and the waiting room (at the same level) will be in a structure spanning the tracks. The baggage, express and mail rooms will be at the track level (on the lower floor of the main building), with elevators and chutes to subways serving the several platforms.

Seattle, Wash.—The new passenger terminal now under construction for the Harriman Lines involves the expenditure of nearly $1,000,000 (exclusive of property costs), within the limits of a tier of five city blocks, having a width of 240 ft. and a length of 1,500 ft. Four main tracks lead from the south to this passenger terminal, passing first (on their west) a coach cleaning yard having a capacity of 250 coaches, and then (on their east) a coach storage yard (capacity 60 coaches). In this latter yard passenger trains are to be made up, and are then connected by crossovers and ladder tracks to the eight stub tracks and six through tracks, which constitute the gridiron serving the station. These latter tracks have a length varying from 430 ft. to 1,500 ft. They are arranged in pairs spaced

12 ft. centers, between which are the 20-ft. platforms, sheltered by the butterfly type of shed, constructed of light steel forms. These platforms are 680 to 920 ft. long, 8 in. above the rails.

The streets adjoining all four sides of the area above noted are carried on viaducts constructed partly of reinforced concrete and partly of structural steel, at an elevation of approximately 27 ft. above the level of the tracks. Two tracks are located under these viaducts, one on the easterly side of the yard and one on the westerly. The supporting structure along the easterly side of the yard carries 16 ft. of Fifth Ave. South and has a cantilevered sidewalk extending 8 ft. over the railway property. It is supported on the east by a retaining wall of reinforced concrete, having an average height of 30 ft. and a length of 1,633 ft.

The station building is located at the north end of the yard, being 145 ft. in width by 185 ft. in length and having three stories above the level of the adjoining streets. The building is constructed of reinforced concrete and is faced with brick, trimmed with stone. The roof is supported on steel trusses. The building is set back from the street on the north a distance of approximately 40 ft. for carriage and bus accommodation. The main waiting room is at the elevation of the street. At its southern end is a concourse 45 ft. wide and extending the full width of the yard, connecting at its ends with Fourth and Fifth Aves. Stairs from this give access to the platforms on the track floor.

Ample provision has been made for baggage storage and for express and mail accommodation, the entire area of the track floor of the building being devoted to these purposes. Baggage may be received both at the street floor (thence taken by means of elevators to the track floor), or may be delivered directly to the main baggage room by means of an incline, permitting the driving of wagons from the street down to the track floor and thence under the viaduct to the depot building. The two upper floors of the building are devoted to housing the general offices of the railway company. A power plant located in a separate building will furnish heat, light and compressed air. The plan of this station is shown in Fig. 10.

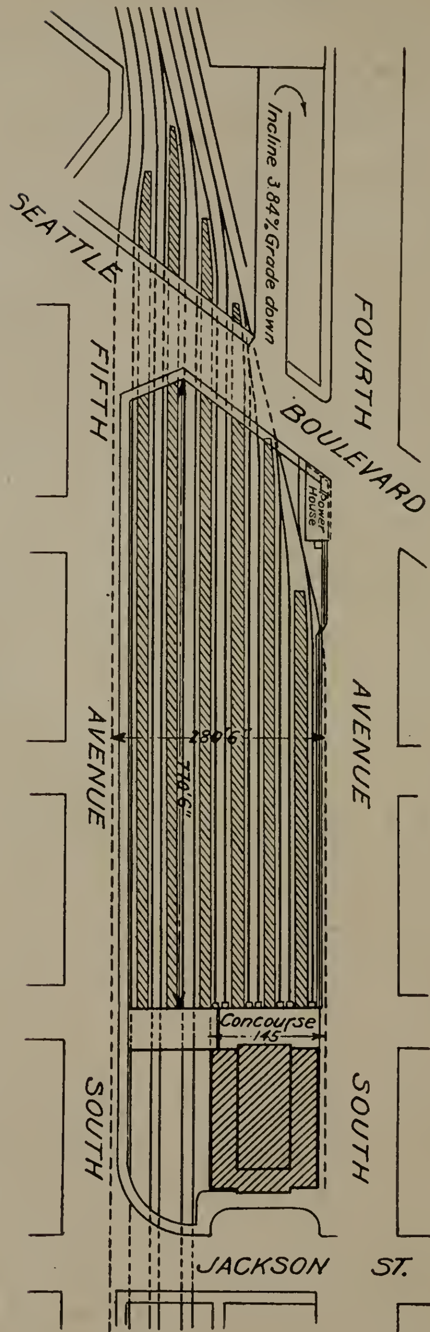
SEATTLE
BOULEVARD
Incline 3.84% Grade down
FIFTH AVENUE
FOURTH AVENUE
Power House
280'6"
770'6"
Concourse
145
SOUTH
SOUTH
JACKSON ST.

Fig. 10.

Appendix F.

LIST OF IMPORTANT ARTICLES ON STATIONS, YARDS AND TERMINALS: 1910.

Large Passenger Stations.—Reports presented at the International Railway Congress (Berne, Switzerland), 1910. Published in different numbers of the "Bulletin" of the Congress.

Passenger Terminal Station of the Pennsylvania R. R. in New York.—Engineering Record, April 9, 16; Railway Review, September 10; Engineering News, September 15.

Passenger Transfer Station at Harrison, N. J.; Pennsylvania R. R. (for New York Terminal Service).—Railway Review, July 2.

Proposed Rearrangement of Passenger Terminals at Chicago.—Engineering News, February 24.

Passenger Terminal Station of Chicago & Northwestern Ry. at Chicago.—Railroad Gazette, August 14 (1908); July 6 (1909); February 11, March 17 and July 15 (1910); Engineering Record, June 18.

Union Passenger Station at Kansas City.—Railroad Gazette, March 18.

Union Passenger Station at Winnipeg.—Engineering Record, June 18.

Two Union Passenger Stations at Salt Lake City.—(A) For the Oregon Short Line and the San Pedro, Los Angeles & Pacific Ry.; Railway Review, January 29. (B) For the Western Pacific Ry. and the Denver & Rio Grande Ry.; Railway Review, September 24.

Passenger Terminal Station at Seattle; Oregon & Washington Ry.—Railroad Gazette, January 21.

Passenger Stations of the Western Pacific Ry.—Railway Review, May 28, September 24.

Trainshed of Bush Type for Chicago Terminal; Chicago & Northwestern Ry.—Railroad Gazette, March 17.

An English Passenger Terminal with Long Platforms for Two Trains.—Engineering News, February 11 (1909).

Train Indicators for Passenger Stations.—Railway Review, May 21.

Movements of Passengers on Platforms and Stairways.—Railroad Gazette, March 18.

Passenger Station Economics.—Railroad Gazette, January 21.

Electrification of Railway Terminals at Boston.—Engineering News, March 10; Electric Railway Journal, November 19.

Electrification of Railway Terminals in Chicago.—Engineering News, December 24 (1908).

The Demand for Electric Operation of Steam Railway Terminals in Large Cities.—Engineering News, January 14 (1909).

How Much Should Railways Spend in New Passenger Stations.—Engineering News, October 28 (1909).

Gravity Freight Classification Yard at Northumberland, Pa.; Pennsylvania R. R.—Engineering News, November 17.

Standard Freight Stations; Virginian Ry.—Railway Review, May 7.

Freight Transportation by Narrow-gage Underground Electric Railways in Chicago.—Engineering News, July 28, November 17.

Operating Terminals and Freight Traffic.—Engineering News, April 7 (p. 405).

Cost of Terminal Freight Handling at the Port of New York.—Engineering News, March 24 and 31.

Economic Freight Transfer at Railway Terminals and Shipping Docks. —Engineering News, March 3 (pp. 235 and 253).

Arrangement of Tracks on Steamship Piers.—Engineering News, September 29.

Waterway Terminals.—Part III of the Report of the Commissioner of Corporations (Herbert Knox), Washington, D. C.

Ownership of Harbor and Waterway Terminals in the United States.—Engineering News, October 6.

Terminals for River and Waterway Traffic.—Engineering News, March 31 (p. 377), May 5 (p. 514), June 2 (p. 648).

Decline of Water Transportation in the United States.—Engineering News, March 3.

Waterway Transportation in Europe.—Railroad Gazette, January 8, 14, 21 and 28; March 25.

Steel Barges for River Traffic.—Railway Review, June 18.

Freight-Handling Telferage System for the Mississippi River Terminal at Memphis; Illinois Central Ry.—Railroad Gazette, June 10.

River Terminal and Freight Transfer Incline at Montgomery, Ala.—Engineering News, July 14.

Freight Unloading System in the Harbor of Manaos, Brazil.—Engineering News, September 8.

Freight-Handling Conveyors at a Steamship Pier at Seattle, Wash.—Engineering News, November 10.

Mechanical Handling of Freight at Transfer Stations.—Railway Review, February 12.

Fifteen-ton Freight Handling Derrick; M., St. P. & S. S. M. Ry.—Engineering News, July 7.

Motor Trucks for Handling Baggage at Stations.—Railway Review, January 8; Railroad Gazette, November .

Cars for Hauling Baggage Trucks Between Separate Terminal Stations; Hudson & Manhattan Underground Ry., New York.—Railway Review, April 9.

Steel Cars for the Chicago Freight Tunnel Service.—Engineering News, November 17.

DISCUSSION.

(The report on Yards and Terminals was presented by the Chairman, Mr. F. S. Stevens, Engineer Maintenance of Way, Philadelphia & Reading Railway.)

Mr. William McNab (Grand Trunk) :—Before this Committee presents its report, I do not think it would do them any harm, nor would it do this Association any injury, if I were to quote from a letter received by me two months ago from the General Manager of a European railway. I quote it in order to show in what esteem this Association is held elsewhere. I bring it up now because the quotation is in connection with such work as this particular Committee is engaged in. The letter is from the General Manager of one of the important railway systems in Great Britain. I had sent him a copy of our Transactions of last year. He says:

"I have delayed replying to you until I could find an opportunity to peruse the volumes. I have now done so. I must say that I found them most interesting. I was in particular interested in the plans of the terminal stations, and I have shown this part of the report to our Chairman, Sir Charles Renshaw, in connection with the reconstruction of a large terminal station which we have under way at the present time."

I present this extract from the letter, not particularly to throw any bouquets at the Committee, but more to show them, as well as the whole Association, that we are favorably recognized across the seas.

Mr. F. S. Stevens :—Under paragraph 1 of our instructions, the Committee was instructed to "consider a revision of the Manual; if no changes are recommended, to make statement accordingly." The Committee thought best to recommend a few changes, and these are given in the report.

In connection with this matter I wish to say that since our report was finished, request has been made that the definitions for separating yard and switching district remain as at present in the Manual. These two definitions were eliminated last year, but on reconsidering the subject we think it better to retain them. We therefore move the adoption of the matter submitted and the retention of the two definitions referred to.

The President :—We will take up the definitions in order, and the Secretary will read them. If there is no objection to them, as read, they will be considered approved.

The Secretary :—"Transfer Slip.—A protected landing place for transfer boats with adjustable apron or bridge for connecting the tracks on the land with those on the transfer boats.

"Incline.—An inclined track (or tracks) at a protected landing place, with adjustable apron and cable for connecting to the tracks on a transfer boat."

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis) :—Under this definition you could not have an incline without an apron. I understand that an apron is something separate from the incline—I refer rather to the cradle that carries the aprons by which the car is loaded on the boat; this is not necessarily a part of the incline.

Mr. B. H. Mann (Missouri Pacific) :—The last part of the definition makes it apply only to such complete facilities as are provided for transferring the cars from shore to boats. Do I understand Mr. Rose wants the definition to apply to something else?

Mr. Rose:—I am asking for information. I know of a case where a cradle got away from the incline and went down into the river. It was an incline just the same.

Mr. Jos. O. Osgood (Central of New Jersey) :—I do not understand about the cables. Are there not many inclines which do not have cables? Some I happen to know of do not.

Mr. Mann:—On the rivers we have inclines, as they may be called, for the repairing of river boats—to raise the boat out of the water, so it can be repaired in the ship yard; but the definition of the incline as meant here is a complete installation ready for service, including the facilities necessary to transfer the car from the boat to the shore, and without these extra facilities it is not complete and ready for business.

The President:—Is there any further discussion? If not, we will pass on to the next subject.

The Secretary:—"Export Pier.—An open or covered pier at which freight is unloaded and stored, mainly for shipment on ocean or coasting vessels."

Mr. E. R. Lewis (Michigan Central) :—I ask if it will be acceptable to the Committee, as this is a general term, to say, "A pier," eliminating the words, "a covered pier."

Mr. McNab:—I think the remarks just made are well taken. The only change from the previous form is the classification, by saying "an open or covered pier;" before it was simply "a covered pier." Why not say simply "A pier?"

The President:—The Committee accepts that suggestion.

The Secretary:—"Station Pier.—A pier having no rail connections where freight is received and delivered by transfer boats.

"Lead Tracks.—To facilitate train movements the connections of these tracks with the main track should be interlocked, and to facilitate and protect train movements means of direct communication should be established.

"Caboose Tracks.—Where conditions permit, caboose tracks should be so located that cabooses can be placed on and removed from them in the order of their arrival, and should be so constructed that cabooses can be dropped by gravity onto the rear of departing trains.

"Coach Cleaning Yard.—The coach cleaning yard should be conveniently located near the terminal station; the tracks should be of sufficient length to hold full trains, with a car cleaners' repair and supply building adjacent thereto."

Prof. S. N. Williams (Cornell College) :—It would seem better to put the word "and" in that definition, making it read "located near terminal station and track should be of sufficient length," etc.

The President:—That is acceptable to the Committee.

Mr. McNab:—I do not see, in this day and generation of railway progress, why the word "conveniently" is necessary there. It seems that we all ought to know that a coach cleaning yard should be in a convenient location to the terminal station. Why put in that word? Let the clause read, "The coach cleaning yard should be located near the terminal station," etc.

The President:—The Committee accepts that amendment.

The Secretary:—"Outbound Freight House.—The outbound freight house should be narrow (25 feet is a good average width) and not more than four tracks should be provided. The side toward the tracks should have a platform, and should be fitted with doors moving vertically between the posts.

"Where a great number of cars are required, the average trucking distance will generally be least and trucking through cars will be avoided if the freight house is built at right angles to and at the back ends of a series of tracks built in pairs with covered platforms between."

Mr. Rose:—It will take some study to think that over. It seems to me the freight could be handled more economically by building the freight house alongside of the track, switching the cars to the freight house, rather than trucking the freight down alley-ways, at right angles to the freight house.

The President:—The Committee has already stated that they wish to retain the definitions now in the Manual referring to "operating yards" and to "switching district." It is necessary to include that in these recommendations in order to embody them in the Manual.

The Secretary:—"Separating Yard.—A yard adjoining a receiving yard, in which cars are separated according to district, commodity, or other required order.

"Switching District.—That portion of a railway at a large terminal into which cars are moved and from which they are distributed to the various sidetracks and spurs to freight houses and manufacturing establishments served from this district, by yard or switching engines."

The President:—The two definitions just read are already in the Manual and will not be retained, unless there is objection.

The question is on the adoption of the Committee's suggestions and recommendations as submitted. The Chairman has already moved that the definitions and recommendations be incorporated.

(The motion carried.)

Mr. F. S. Stevens:—Paragraph 2 of the instructions to the Committee refer to the development of mechanical handling, as a means of promoting rapidity and economy in the handling of freight. This matter has been brought up to date, and appears in Appendix A as information.

The President:—There is a very interesting installation of devices for handling freight being installed in the Missouri, Kansas & Texas freight depot in St. Louis. If there is any member of the Missouri, Kansas & Texas System present, we would like to hear from him on that interesting subject, or perhaps Mr. Condron can give us some information about that installation.

Mr. T. L. Condron (Consulting Engineer):—I feel hardly qualified to speak about the new freight station of the Missouri, Kansas & Texas Railway, as all of the credit for that project is due to Mr. Fisher, Chief Engineer of that road, but if Mr. Fisher is not here, I can perhaps tell you a little about the station being built in St. Louis, we having designed the structural steel and reinforced concrete as Consulting Engineers for the road. The freight station is designed for both inbound and outbound L. C. L. freight. The building is of structural steel, 400 ft. long and 233 ft. wide. It is so located that the street on the east of the building is about 20 ft. below the street on the west; east of the building is the street on which are the tracks of the Terminal Railway of St. Louis. The street on the west is Broadway. The lower level of the station is on the grade of the railroad tracks or about 20 ft. below the level of Broadway, and on this lower level are twelve tracks, each 400 ft. long, providing for 120 freight cars of average length. Between the twelve lines of freight cars are six lines of 12-ft. platforms, and above the platforms are 57 hatchways in the main floor above. The second or main floor on the level of Broadway has four driveways, each 38 ft. wide, running across the entire width of the building at right angles to the tracks so that there is about 1,000 ft. of driveway, with a freight platform on each side of the driveway to which teams can back up or drive alongside. The platform surface of the second floor is 3 ft. 9 in. above the street level, and covers something over one acre. The freight will be received from the wagons that come into the freight house onto these platforms, ready to be weighed and distributed by means of overhead telphers, running transversely and longitudinally on monorails to the various hatchways, so as to reach any one of the 120 freight cars on the lower level. Likewise, freight coming in will be lifted by means of these telphers to the platform level above, and distributed to the wagons. The telphers are carried on I-beam runways suspended from the structural steel framing of the third floor, the story height between the second and third floors being 34 ft.; the column spacing in the building being 40 ft. in one direction and 38 ft. in the other; so that they are enormously large panels for such heavy construction, the building being designed for a live load of 300 lbs. per ft. The structure is now being erected, and contemplates in addition to the two levels I have described, two additional levels for storage and office purposes. The upper stories are not being built at this time, except an office space on the south end of the building, which is 40 ft. wide by 233 ft. long. The system of electric telphers is being installed by the Sprague Electric Company, the details of which it is not possible for me to describe, but there is a system of switches and turnouts, so that the telphers can be run to any part of the freight house and handle freight from any one part to any other part. The telphers will pick up the freight, which, in the case of small packages, will be loaded onto so-called flat boards; the flat boards having small caster wheels under them and suspended from a frame, so that they can be picked up by the hook of the telpher and raised through the hatchways, raised above the team floors, and passed over the area. The working out of this will shortly be open to inspection, as they hope to have the freight house in operation about the 1st of May, I understand.

The President:—The Chair believes that this is the first application of the telpher system to the handling of L. C. L. freight in this country in a freight station, and it will be very interesting to watch the development of this particular installation.

Mr. Condron:—In addition to the telphers there has been placed on the columns alongside of the driveways, jib cranes, so as to handle heavy freight from the wagons to the platforms. The columns in that building are necessarily very heavy, being 55 ft. in length, extending from the foundations two stories to the third-floor level. The entire framework of steel is to be fireproofed with concrete.

Mr. F. S. Stevens:—I would like to ask Mr. Condron if these telphers are used for transfers upon those twelve tracks also, in addition to the movement to and from the house; that is, is freight transferred from car to car?

Mr. Condron:—No. it would not be transferred from car to car unless it was lifted up to the next floor, and carried over in the manner described.

The President:—Is it the intention to dispense with the handling of freight by hand trucks entirely?

Mr. Condron:—Yes; as the platforms will be 400 ft. long and 12 ft. wide, the only means of passing up and down those platforms will be by means of trucking; but it is not intended that there will be any amount of freight moved along the platforms between the cars.

Mr. F. S. Stevens:—Would it be possible to economically and promptly unload one car and distribute the freight into the other 119 cars so placed?

Mr. Condron:—Yes; it would be much more economical to do it, they anticipate, than by means of trucking over a large house. It might be said in this connection, if the station is used only by the Missouri, Kansas & Texas, it will be largely a terminal station. If it is used by any other road with the Missouri, Kansas & Texas, as is highly probable, there will be interchange of freight, the working out of which I am not familiar with.

Mr. F. S. Stevens:—That is a question of transfer, and if it would be available for that, it would be of much larger application than if from the house to the cars or from the cars to the house only.

Mr. Condron:—The freight will have to be raised 16 or 20 ft. vertically above the car floor level to reach the platform above, and the distribution there would be the same as the distribution of wagon loads or other freight. That would apply equally as well there as other distribution by trucking.

Mr. A. W. Thompson (Baltimore & Ohio):—I want to call attention to the Baltimore & Ohio pier in Baltimore, where a telpher system has been in operation about a year. I think possibly the Committee has not gotten any data on that pier and how it is being handled. This system is a Sprague system, similar to the one just described in the handling of L. C. L.

The President:—Do you handle much L. C. L. freight there? Isn't it principally carload freight?

Mr. Thompson:—It is both. The largest percentage is L. C. L. It comes in and is distributed in carload lots. It is quite similar to the business done in an ordinary freight house.

The President:—If there is no further discussion, we will pass to the next subject, the design of typical track layout, for passenger terminals of medium size.

Mr. F. S. Stevens:—This subject was treated last year in a preliminary way, and reported on at our last annual convention. The present report is supplemental and finishes the subject this year. The information that was obtained as to the physical characteristics, and the main operating features of 26 passenger stations or terminals of medium size, is given in Appendix C, in tabulated form, for ready reference; this gives practically all of the information obtainable as to these 26 stations. The typical track layouts that have been submitted are intended to illustrate the text of the report, and most of the features that are shown therein are merely incidental. The main feature and the principal object for submitting the diagram is to show the manner in which it is proposed to get trains in and out promptly; the locations of engine-house, water cranes, etc., are incidental features which we do not consider have any particular bearing on this case; they are merely inserted to show what might be done in a terminal of that character, if conditions permitted.

We were instructed to confer with the Committee of Signals and Interlocking as to the adaptability of the layout for the application of interlocking. Only one member met with us, therefore that Committee was not fully represented. As stated in the report, the plans which are submitted met with the approval of that one member.

In connection with these instructions we submit two conclusions covering the subject generally, and move for the adoption of them, to be published in the Manual.

The Secretary:—"(1) To avoid excessive cost in providing passenger terminal facilities largely in excess of ordinary requirements, it is imperative that provision be made for economical, efficient and practically continuous operation of the terminal during the periods of greatest activity which may reasonably be expected within a period of, say, ten years. To this end, the track layout must be designed to permit incoming and outgoing movements to be made at the same time, without interference, as far as it is possible to arrange this."

The President:—The Chair would like to ask the Committee, if in the place of ten years, it would not be wise to extend the time of the provision for economical, efficient and practically continuous operation during the periods of greatest activity, which may be reasonably expected to twenty or twenty-five years. Ten years is a short period.

Mr. F. S. Stevens:—The ten year period was discussed at our meeting and was agreed to as a reasonable time limit to be placed on a question of that kind.

Mr. George W. Kittredge (New York Central & Hudson River Railroad):—I think a period of ten years is too short a time for which to design a terminal station. I venture that any plant of considerable magnitude which only provided for a ten years' growth would be outgrown before it is completed.

Mr. F. S. Stevens:—If it is proper, I would like to invite attention to the fact that this report is based on the consideration of passenger terminals of medium size, nothing like the Grand Central Station in New York.

Mr. Kittredge:—The medium station of to-day is the large station of to-morrow, and my remarks still apply.

Mr. McNab:—I ask Mr. Kittredge, when the Grand Central Station improvements were made a few years ago, how long they were figured for? Within my recollection, which does not go so very far back, there have been three changes made in that terminal. Mr. Kittredge is speaking from experience, and he wants to justify his views.

Mr. Kittredge:—I am sorry I cannot answer Mr. McNab as to what my predecessors figured on as to future growth, when the last revision was made, but it was not ten years after they made the revision in 1899 or 1900 when they began to rebuild on the present basis, and as an example of what growth has taken place since work started on the present terminal, I will say that the first contract with the city provided for the work being completed in five years from the date of beginning, to be completed July 1, 1908. Prior to July 1, 1908, we had to go to the city for an extension of time. We showed the city at that time that so far as excavation and construction work is concerned, we had then completed 108 per cent. of all the work contemplated in 1903, when the improvement was begun, but as a matter of fact, it was only about 40 per cent. of what was then under contemplation.

Mr. McNab:—No doubt that is an exceptional case; but I think the Committee's report and its recommendation should stand in that respect.

Mr. Kittredge:—I would move an amendment that the time be extended to twenty years instead of ten years.

(The motion carried.)

The Secretary:—"(2) At passenger terminals where large quantities of baggage and express must be handled, and it does not appear desirable or expedient to provide intermediate platforms to be used exclusively for this service, it is recommended that (where conditions permit), baggage and express be received, delivered and handled below the train floor, and raised and lowered by elevators, conveniently located, to avoid interference with the movement of passengers."

Mr. Kittredge:—I ask why baggage and express should be received, delivered and handled below the train floor, rather than below or above?

Mr. F. S. Stevens:—The reason that entrance below is shown is because general conditions will permit that construction better, and for the further reason that the head room can be very much less. If the handling of the baggage and express is above the train floor, probably not less than 18 ft. clear would suffice. If it is below, 12 ft. is ample, and probably 10 ft. would suffice.

Mr. Kittredge:—In connection with the terminal at New York, where we have a double-deck structure, we find it much more economical to handle baggage, mail and express that comes in on the upper level, above the tracks, while for that which comes in on the lower level it is more economical to handle it below the tracks. I think the words "above or below" should be substituted for the word "below."

Mr. E. B. Temple (Pennsylvania Railroad):—I think that is a good suggestion of Mr. Kittredge. When this conclusion was drawn, it was not taken into consideration that some stations are underground. I am glad to know that you have made the change to twenty years instead of ten years. At the Broad Street Station, Philadelphia, we find that the number of passengers carried has increased 50 per cent. in the last ten years. For thirty years, or even since the station was built, we have been enlarging every ten years, and are now up against the problem again.

Wr. W. H. Courtenay (Louisville & Nashville):—The discussion is being based on the largest terminals we have in the United States, and my understanding of these conclusions is that they apply to passenger terminals of medium size. Passenger terminals like that of the New York Central and the Pennsylvania in New York City and the Pennsylvania Broad Street, Philadelphia, are not terminals of medium size. It would seem to me that a terminal of medium size is a terminal in a city of 100,000 people or less—I would take that to be medium size. In cities of medium size, where the ground is of reasonable cost—you might put it medium cost—it would be cheaper to handle the baggage on the same level. I do not think the Committee should recommend for passenger terminals of medium size that the baggage should be handled on a separate level, because in such cases it is very expensive, and hardly justified.

The President:—Attention is called to the fact that the conclusion says, "it is recommended that (where conditions permit), baggage and express be received, delivered and handled below the train floor," etc.;

in such cases where it does not appear desirable or expedient, to provide intermediate platforms to be used exclusively for this service.

Mr. Courtenay:—That is relative. Take passenger terminals in cities of from 40,000 to 60,000 people, there is at times a good deal of baggage to be handled. It is relative—what would be a large amount of baggage to be handled in a terminal of that character would be a small amount to be handled in a terminal in New York or Philadelphia. As this recommendation is limited to terminals of medium size, I think the recommendation should be such as is appropriate to terminals of medium size. I do not think the necessities of the great terminals in New York, Philadelphia and Chicago ought to govern the design of terminals in small cities.

Mr. E. B. Temple:—We consider that the ideal terminal should be either above the street level or below it, where cross-streets exist, and it does not take any more costly facilities to have the baggage placed on a truck and run on an elevator in the case of such a station and taken up or down to the platforms in this manner.

Mr. Courtenay:—I would like to know the ideas of the Committee about a passenger terminal of medium size. The conclusions will hinge on that. What do they consider a terminal of medium size—what is the population of the city in which such a terminal would ordinarily be located?

The President:—The Committee wishes to ask if you have any alternative conclusion to offer in place of conclusion 2, which expresses their opinion as to the requirements of a medium-sized passenger terminal?

Mr. Courtenay:—Since the question has been asked, my private opinion is that in passenger terminals of medium size it is better to handle the baggage on the same level. So far as I know, passenger stations of medium size are generally located on the ground surface, neither above nor below. There are exceptions, of course, but I know of a large number of passenger terminals of medium size where the whole layout is substantially on the street level, and it would seem that for such a terminal the cheapest way to handle baggage would be to handle it on the same level. If there is much baggage to be handled, it would seem desirable to provide intermediate platforms. I do not understand why it should not be desirable to provide intermediate platforms on which to handle baggage if there is a great deal of baggage to be handled. These remarks do not apply to the great passenger terminals of the larger cities, but do apply to medium-size passenger terminals.

Mr. C. H. Spencer (Washington Terminal Company):—It has been stated that we are considering only passenger terminals of medium size, therefore, I do not think any remarks concerning passenger terminals of larger size would apply. I would call Mr. Courtenay's attention to the fact that a number of States are agitating the question of the elimination of grade crossings. Some have already passed laws requiring grade crossings to be eliminated. This means that terminals are bound to be elevated or depressed. This agitation is becoming greater and greater continually, and in presenting this report the Committee presented what they thought was an ideal terminal to meet what may be expected in legislation of this class. Certainly the ideal condition is the terminal that does away with the necessity of grade crossings of any kind.

Mr. G. H. Burgess (Delaware & Hudson):—The Committee in its report shows a list of what are considered medium-sized terminals, but 13 of the 26 terminals are either above or below the street level. It seems to me that that largely answers the question Mr. Courtenay has raised as to the size we consider as a medium-sized terminal, and also proves the Committee's case as being either over or under the street level.

Mr. Courtenay:—That is a point on which I want light. Evidently the Committee considers the stations in this table to be medium-sized stations and their conclusions are based upon stations of that character; if that is correct, it becomes a different proposition. That was not my idea of a medium-sized terminal. The Union Station in Cincinnati is not a very large one, but it is not my idea of a terminal of medium size. The Philadelphia station, a pretty big town, is given here in this list; also Baltimore, and various others. The Union Station at Birmingham is not my idea of a station of medium size—it is a huge affair. My idea of a station of medium size and my opinion of what the Committee was discussing was stations in cities of less than 100,000. I think we should cut out the word "medium" in the caption of this report, if it is to apply to stations like those in New York, Philadelphia, Baltimore, Cincinnati, etc.

Mr. C. H. Spencer:—I would suggest that the Committee consider the question from the standpoint of the amount of business done in the station rather than the population of the city where the station is located. You will notice in the table that the number of trains originating and departing gives an idea of the amount of business being done in the stations. That is what should govern rather than the size of the city.

Mr. E. B. Temple:—The table referred to does not include any of the large terminals in New York, Philadelphia and Chicago. The Philadelphia station cited is not the Broad Street Station of the Pennsylvania Railroad.

Prof. Williams:—Would it not be better, in view of the fact that we changed the previous paragraph to twenty years, to take into account the possible growth in business of these terminal stations during the next twenty years, and is it not likely that the business will increase to such an extent as to make it desirable to have this arrangement of the terminal facilities from the present time on?

Mr. F. S. Stevens:—I will say that the Committee considered the question of providing facilities greatly in excess of present requirements, or requirements that could not be expected in the near future, but considered that it would be somewhat extravagant to provide them. That is the reason that the lesser period was chosen; to provide facilities for twenty or twenty-five years hence would often involve interest charges largely in excess of the cost of providing the facilities later on when they might be needed.

The President:—Is there any further discussion on the subject? The motion of the chairman is to adopt the Committee's conclusions, as amended. That embraces both conclusions 1 and 2, as amended.

Mr. McNab:—As brevity with efficiency is desired by this Association, I would ask the Committee if they would accept the elimination of the words "desirable or" in the second line of conclusion 2?

The President:—The Committee accepts that. Are you ready for the question?

(The motion carried.)

The President:—If there is no further discussion on this Committee's report, the Committee will be relieved with the thanks of the Association.

REPORT OF COMMITTEE VII.—ON WOODEN BRIDGES AND TRESTLES.

(Bulletin 129.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The work assigned by the Board of Direction was as follows:

(1) Consider revision of Manual; if no changes are recommended, make statement accordingly.

(2) Continue to co-operate with Committee Q of the American Society for Testing Materials, and other associations, in the preparation, revision and adoption of uniform standard specifications for structural timber.

(3) Continue the study of principles and methods of pile-driving, including information on pile-drivers and equipment, analysis of practical experience in pile-driving, the strength of sheet piles, recommended types of equipment, of sheet piles, of concrete piles, and of formulas for bearing power.

(4) Make concise recommendations for next year's work.

SUB-COMMITTEES.

After some preliminary discussion the members of the Committee were assigned to the following Sub-Committees:

To consider further revisions of the Specifications for Southern Yellow Pine: F. H. Bainbridge.

To consider further revisions of the Specifications for Douglas Fir and Western Hemlock: L. J. Hotchkiss.

Piles and Pile-driving: R. D. Coombs, Chairman.

(a) Sheet Piles: C. C. Wentworth, Chairman; L. J. Hotchkiss, I. L Simmons, Hans Ibsen.

(b) Details: W. S. Bouton, Chairman; J. A. Lahmer.

(c) Mechanical Pile Protection: J. A. Lahmer, Chairman; F. H. Bainbridge.

(d) Pile Records: F. B. Scheetz, Chairman; Hans Ibsen.

(e) Concrete Piles: P. H. Wilson, Chairman; R. D. Coombs, J. A Lahmer, L. J. Hotchkiss.

(f) Pile-drivers: F. B. Scheetz, Chairman; W. S. Bouton, G. R. Talcott.

(g) Analysis of Practice: F. H. Bainbridge, Chairman; F. E. Bis sell, H. S. Jacoby, I. L. Simmons.

(h) Bearing Power and Formula: F. E. Bissell, Chairman; R. D. Coombs, F. B. Scheetz.

(i) Water Jet: G. R. Talcott, Chairman; L. J. Hotchkiss, F. B. Scheetz, C. C. Wentworth.

(j) Overdriving: L. J. Hotchkiss, Chairman; H. S. Jacoby.
(k) Enlarged Foot, Screw, and Disc Piles: P. H. Wilson.

COMMITTEE MEETINGS.

Two meetings of the Committee were held in Chicago in March, 1910, at the time of the last annual convention, to consider the general plan of work for the ensuing year and the arrangement of Sub-Committees. The members present were: March 15, L. J. Hotchkiss, Hans Ibsen, Henry S. Jacoby, J. A. Lahmer, C. C. Wentworth; March 16, W. S. Bouton, L. J. Hotchkiss, Hans Ibsen, Henry S. Jacoby, J. A. Lahmer, C. C. Wentworth.

On September 24 a meeting was held at the offices of the Association in Chicago, to receive and discuss the reports of the Sub-Committees. Those in attendance were: F. H. Bainbridge, L. J. Hotchkiss, Henry S. Jacoby. G. R. Talcott, C. C. Wentworth.

REVIEW OF THE REPORT OF 1910.

Amendments to the standard definitions and to the Specifications for Metal Details used in Wooden Bridges and Trestles were recommended and adopted. (Proceedings, Vol. 11, pp. 178, 179.)

Standard Specifications for Southern Yellow Pine, and for Douglas Fir and Western Hemlock Bridge and Trestle Timbers were recommended and adopted. (Proceedings, Vol. 11, pp. 180, 181, 182, 183, and 234.)

On the recommendation of the Committee the Definitions for Structural Timber were referred to the Board of Direction for publication in the Manual. (Proceedings, Vol. 11, p. 184.)

A progress report was submitted as information and for discussion by the Association, in which were included: Cuts of various pile record forms, splices in timber piles, pile shoes; illustrated discussion on overdriving, and mechanical protection; an illustrated historical account of concrete piling and a description of most of the types in use, together with a summary of the advantages and possible disadvantages of concrete piles; an original article by E. P. Goodrich on the Supporting Power of Piles.

REVISION OF THE MANUAL.

No revision of the Manual in regard to the Specifications for Southern Pine or for Douglas Fir and Western Hemlock is recommended, as it is considered that these specifications should be given a longer commercial use, in order to develop points for possible modification.

CONCLUSIONS.

Your Committee recommends the adoption of the following conclusions:

(1) That the Pile Record Form be adopted as a standard.
(2) That the Principles of Practice for Pile-Driving be adopted.

(3) That the report on Piles and Pile-Driving be received as information.

(4) Piling can be protected against marine wood borers by filling sand between the piles and vitrified clay pipe placed around the piles from a point a foot or two below mud line to the same distance above high tide. The expense is such that it is not advisable to apply this treatment to piling which has not been protected against decay.

Respectfully submitted,

HENRY S. JACOBY (*Chairman*), Professor of Bridge Engineering, Cornell University, Ithaca, N. Y.

F. H. BAINBRIDGE (*Vice-Chairman*), Resident Engineer, Chicago & Northwestern Railway, Necedah, Wis.

F. E. BISSELL, Civil Engineer, Cleveland, Ohio.

W. S. BOUTON, Engineer of Bridges, Baltimore & Ohio Railroad, Baltimore, Md.

R. D. COOMBS, Consulting Engineer, New York, N. Y.

L. J. HOTCHKISS, Assistant Bridge Engineer, Chicago, Burlington & Quincy Railroad, Chicago, Ill.

HANS IBSEN, Bridge Engineer, Michigan Central Railroad, Detroit, Mich.

J. A. LAHMER, Principal Assistant Engineer, Kansas City Southern Railway, Kansas City, Mo.

F. B. SCHEETZ, Chief Engineer, Kansas City Bridge Co., Kansas City, Mo.

I. L. SIMMONS, Bridge Engineer, Chicago, Rock Island & Pacific Railway, Chicago, Ill.

G. R. TALCOTT, Assistant Division Engineer, Baltimore & Ohio Railroad, Garrett, Ind.

C. C. WENTWORTH, Principal Assistant Engineer, Norfolk & Western Railway, Roanoke, Va.

P. H. WILSON, Civil Engineer, Philadelphia, Pa.

Committee.

Appendix A.

PILE RECORD FORM.

Pile Record of Bridge..
LOCATION..
Weight and Kind of Hammer..................................**Date**..............**19**....

Bents Numbered from North or East End **Piles numbered from Left to Right**

Date	Bent No.	No. of Pile	Size of Pile			Kind of Wood	Cut-off	Base-rail to Ground	Total Penetrat.	Av. Last Five Blows		Kind of Soil	Remarks
			Tip End	Butt End	Length					Drop of Ram'r	Penetrat.		

Appendix B.

PILE-DRIVING—PRINCIPLES OF PRACTICE.

(1) A thorough exploration of the soil by borings, or preliminary test piles, is the most important prerequisite to the design and construction of pile foundations.

(2) The cost of exploration is frequently less than that otherwise required merely to revise the plans of the structures involved, without considering the unnecessary cost of the structures due to lack of information.

(3) Where adequate exploration is omitted, it may result in the entire loss of the structure, or in greatly increased cost.

*(4) The proper diameter and length of pile, and the method of driving, depend upon the results of the previous exploration.

(5) Where the soil consists wholly or chiefly of sand, the conditions are most favorable to the use of the water jet.

(6) In harder soils containing gravel the use of the jet may be advantageous, provided sufficient volume and pressure be provided.

(7) In clay it may be economical to bore several holes in the soil with the aid of the jet before driving the pile, thus securing the accurate location of the pile, and its lubrication while being driven.

*(8) The water jet should not be attached to the pile, but handled separately.

(9) Two jets will often succeed where one fails, in special cases a third jet extending a part of the depth aids materially in keeping loose the material around the pile.

(10) Where the material is of such a porous character that the water from the jets may be dissipated and fail to come up in the immediate vicinity of the pile, the utility of the jet is uncertain, except for a part of the penetration.

(11) A steam or drop hammer should be used in connection with the water jet, and used to test the final rate of penetration.

(12) The use of the water jet is one of the most effective means of avoiding injury to piles by overdriving.

*(13) There is danger from overdriving when the hammer begins to bounce, provided the head of the pile is not broomed. Overdriving is also indicated by the bending, kicking or staggering of the pile.

(14) The brooming of the head of a pile dissipates a part, and in some cases all, of the energy due to the fall of the hammer.

*(15) The weight of the hammer should be proportioned to the weight of the pile, as well as to the character of the soil to be penetrated.

(16) The steam hammer is more effective than the drop hammer in securing the penetration of a pile without injury, because of the shorter interval between blows.

(17) Where shock to surrounding material is apt to prove detrimental to the structure, the steam hammer should always be used instead of the

*See amendments, page 306.

drop hammer. This is especially true in the case of sheet piling which is intended to prevent the passage of water. In some cases also the jet should not be used.

(18) In general, the resistance of piles, penetrating soft material, which depend solely upon skin friction, is materially increased after a period of rest. This period may be as short as fifteen minutes, and rarely exceeds twelve hours.

(19) In tidal waters the resistance of a pile driven at low tide is increased at high tide on account of the extra compression of the soil.

(20) Where a pile penetrates muck or soft yielding material and bears upon a hard stratum at its foot, its strength should be determined as a column or beam; omitting the resistance, if any, due to skin friction.

(21) Unless the record of previous experience at the same site is available, the approximate bearing power may be obtained by loading test piles. The results of loading test piles should be used with caution, unless their condition is fairly comparable with that of the piles in the proposed foundation.

(22) In case the piles in a foundation are expected to act as columns the results of loading test piles should not be depended upon unless they are sufficient in number to insure their action in a similar manner, and they are stayed against lateral motion.

(23) Before testing the penetration of a pile in soft material where its bearing power depends principally, or wholly, upon skin friction, the pile should be allowed to rest for 24 hours after driving.

(24) Where the resistance of piles depends mainly upon skin friction it is possible to diminish the combined strength, or bearing capacity, of a group of piles by driving additional piles within the same area.

(25) Where there is a hard stratum overlying softer material through which the piles are to pass to a firm bearing below, the upper stratum should be removed by dredging or otherwise, provided it would injure the piles to drive through the stratum. The material removed may be replaced if it is needed to provide lateral resistance.

*(26) In general, timber piles may be advantageously pointed to a 3-in. or 4-in. square at the end.

*(27) Piles need not be pointed when driven into comparatively soft material.

(28) Shoes should be provided for piles when the driving is very hard, especially in riprap or shale, and should be so constructed as to form an integral part of the pile.

(29) The use of a cap is advantageous in distributing the impact of the hammer more uniformly over the head of the pile, as well as to hold it in position during driving.

(30) The specification relating to the penetration of a pile should be adapted to the soil which the pile is to penetrate.

(31) It is far more important that a proper length of a pile should be put in place without injury than that its penetration should be a specified distance under a given blow, or series of blows.

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*See amendments, page 306.

Appendix C.

OVERDRIVING.

In their reports, in 1909 and 1910 (Proceedings, Vol. 10, pp. 572-576, and Vol. 11, pp. 196-200), the Committee discussed the general subject of overdriving and emphasized its dangers by photographs of overdriven piles. Illustrations could be reported indefinitely, but it is considered more advisable to attempt corrective measures.

It is expected that more rational and explicit instructions to those in charge of field operations will be issued hereafter in order that pile-driving may be given the intelligent attention required in an important operation.

In an endeavor to tabulate the general indications of overdriving, in order that it may be avoided as much as possible, the following suggestions are given for discussion by members of the Association:

(1) In the majority of instances, overdriving is indicated by the behavior of the pile.

(2) The use of a drop hammer instead of a steam hammer and the absence of a water jet often lead to overdriving.

(3) Splices, unless made with great care, are a possible cause of overdriving.

(4) A gradual decrease in the penetration per blow, followed by a sudden and large increase, is often caused by overdriving.

(5) Brooming, shattering, or buckling, of the pile may all be indicative of overdriving.

(6) The bouncing of the hammer is often an indication that further hammering will result in overdriving.

(7) The dull sound of the blow during overdriving is said to be of sufficient difference to be readily distinguishable.

THE WATER JET.

As was stated in a previous report (Proceedings, Vol. 10, p. 567), the first authentic use of the water jet was in 1852, during the construction of a wharf at Decrous Point, Texas. The jet was in general use during the Civil War and tradition gives the early forties as the date of its discovery. It is said that a government engineer standing in the soft mud around a pile-driving operation could not extricate his feet, and that on turning a hose on them he sank deeper and kept sinking as long as he applied the water. After he was extricated, he tried his discovery on the piles, reasoning that if he sank into the mud when a jet of water was applied at his feet, the piles should either sink likewise or offer less resistance to driving.

In the late fifties or early sixties a civil engineer named Stevens applied this method in driving screw piles. In order to facilitate the work of screwing the piles into place he attached a pipe to the side of the pile, passing the nozzle through a hole cut in the disc, thus bringing the water to the point of the pile, the idea being merely to loosen the material and facilitate the screwing down of the pile. On the application of the water it was found that the pile sank readily into place by the action of the jet alone without the use of the screw point.

In a previous report the Committee furnished a bibliography of the water jet, which included a reference to "The Water Jet as an Aid to Engineering Construction," by L. Y. Schermerhorn (1881), Proceedings Engineers' Club, Philadelphia, 1900, Vol. 17; the following is a supplement to that bibliography:

SUPPLEMENT TO BIBLIOGRAPHY OF ARTICLES ON THE USE OF THE WATER JET IN PILE-DRIVING.

Cast reinforced concrete piles. Jour. Assoc. Eng. Soc., Jan., 1909, v. 42, p. 1, and Eng. Contr., 1909, p. 220.

Concrete-pile dike for river bank revetment. Eng. Rec., 1909, v. 59, p. 104.

Handbuch der Ingenieurwissenschaften, 1 Theil, Band 3. "Der Grundbau," 1906. (Has extensive bibliography of pile-driving, with a number of references to water jet, pp. 292-293.)

Heavy concrete-pile foundation. Eng. News, 1908, v. 59, p. 305.

Method of constructing reinforced concrete-pile bents for the Atlantic City Boardwalk. Eng. Contr., 1909, v. 31, p. 126.

Some historical notes on piles. Eng. Contr., 1909, v. 31, p. 245. (Refers to early papers on use of water jet.)

United States patents Nos. 882,520 (1908) and 977,964 (1909).

Water jet in pile-driving. Eng. News, 1889, v. 22, p. 11.

Wellington, A. M., ed. Piles and Pile-Driving, 1893. (Compiled from Engineering News.)

The Missouri River Commission performed a valuable service, by their investigations and use of the water jet, showing its great value in pile-driving. It is said that under a later engineer the Commission found that similar results could be secured more economically and quickly by using a steam hammer instead of a water jet and drop hammer. The obvious inference is that both the water jet and steam hammer used either together or separately will often prove economical.

The water jet is essentially a stream of water forced through a pipe or hose alongside the pile. The flow of water loosens the material, and either washes it out, leaving a depression into which the pile sinks, or by lubricating the surface of the pile reduces the side friction. The use of two jets is generally advantageous in securing a more accurate direction or control of the pile.

Water simply poured on the ground around a pile while driving, not applied as a jet, will in some soils materially facilitate the driving, in one instance on record reducing the number of blows of the hammer nearly 50 per cent. Piles driven this way showed a bearing power equal to those driven on the same work without the use of water.

The jet may be used alone or in conjunction with some other method of driving, or, when the material is suitable, a hole may be jetted, the jet removed and the pile dropped into it and brought to bear by hammering.

On the Missouri River the water jet has been used extensively in sand. It was found there that the greatest penetration that could be obtained with the jet alone was between twelve and sixteen feet; a considerably greater penetration was obtained by forcing the pile down by means of a line attached to the head of the pile and passing through a block to the drum of the pile-driver. Penetrations of 38 feet were obtained when a steam hammer was used with the jet.

When the jet has been used in rather dry, light soils it has been shown by tests that the action of the water tends to puddle the material around the pile and that as soon as the water has been absorbed by the surrounding earth or has been drained away, the jetted piles show a greater skin friction than piles driven in the same material without the use of the jet.

In driving wooden piles, in medium sand, for bridge foundations on the Platte River, two 2-in. jets were used in conjunction with a 6,500-lb. steam hammer.

The jets consisted of 40 ft. of 2-in. gas pipe, 50 ft. of 2-in. rubber-lined hose (pressure 300 lbs. per sq. in.), and a line of 4-in. wrought-iron pipe leading to two duplex 12 by 7 by 12 steam pumps with 6-in. suction and 6-in. discharge, operated by two 40 HP. upright boilers.

The distance from the pumping plant varied from 50 to 1,000 ft. and for the greater lengths a 6-in. pipe was used between the 4-in. pipe and the pumps.

It was found that the first 15 to 20 ft. of penetration was obtained within five minutes after starting the hammer and the jets, but that from 25 to 40 minutes were required to drive the remaining 20 to 30 ft.

The jets were at first fastened to the pile and bent slightly at the tip, but this method was discontinued on account of the times required to connect the jets and because on the completion of the driving the jet pipes were frequently broken, a portion remaining in the ground.

The best results were obtained by churning the jets up and down, keeping the points of both jets at the bottom of the pile. This was done by means of a line attached to the top of the jet pipe and leading over the top of the driver to a point on the ground, or trestle, where it was operated by handpower.

An improvement upon the foregoing equipment would be to operate the jet hoist from a niggerhead of the engine. This method has been used successfully in a number of instances.

There is a difference of opinion upon the part of engineers as to the relative merits of keeping one or all of the jets near the foot of the pile, or of having at least one jet between the surface of the ground and the foot.

In either method the jets should be kept moving in order to facilitate the flow of the water around the pile and to prevent the so-called "freezing" or sticking fast.

In some cases two jets have been used placed on opposite sides of the pile, in order to obtain sufficient volume of water and to keep the pile in alinement. In other cases a single jet, slightly in advance of the pile, has given satisfactory results.

In sand, where the jet acts for some distance, a number of piles may be sunk together. It is claimed that in sand the volume of water is the principal consideration, but that in gravel, etc., a considerable pressure is also required and that holes can be jetted near the foot of the pile into which a boulder will roll out of the way of the pile. On the other hand, it is also stated that in coarse gravel the jet washes out the sand and allows the boulders to roll to the foot of the pile and impede its progress.

In the replies to Circular 123, it was found that of ten users of the jet, six employed it as an aid to the hammer and obtained the final penetration by the hammer alone. In general, a 2-in. pipe was operated by hand-power alongside the pile, though in some instances two pipes were used. The pressures recommended were as high as 200 lbs. per sq. in.; and the material penetrated, usually sand, fine gravel or soft clay.

There appears to have been very little development in the water jet since its first introduction, and but two U. S. patents; the improvements which have been made are in the method of handling. One of the patented devices uses the water pressure to handle the jet pipe, which acts as a movement of the plunger or jet pipe is controlled by valves at the lower end plunger inside of a pipe suspended from a derrick or pile-driver; the vertical of the suspended pipe.

It does not seem desirable to use a jet pipe smaller than about two in. in diameter, on account of the loss of head, due to friction, in the smaller sizes, but this should be reduced at the nozzle in order to increase the velocity, as it is the velocity which loosens the material; the quantity, however, is necessary to bring the material to the surface.

Satisfactory results have been obtained with pressures ranging from that furnished by a single hand pump up to a pressure of 200 lbs. per sq. in. at the pump. The quantity of water supplied at the nozzle runs as high as 500 gallons per minute, 250 gallons per minute giving satisfactory results in compact sand.

STEAM HAMMERS.

Steam hammers are of two general types—single-acting and double-acting.

In the former and older type, the steam pressure is applied to the under side of the piston and raises the hammer, which falls by gravity. The force of the blow depends upon the length of the stroke and the movable weight, and the number of blows depends upon the pressure.

In the double-acting type the steam pressure both raises and lowers the hammer; the force of the blow, as well as the rapidity, being a function of the pressure.

The later apparatus is more compact, lighter and operated with much greater rapidity.

The Cram, Nasmyth and Vulcan hammers are the best known single-acting hammers, while the Clark, Arnott, Goubert and New Monarch are the best known double-acting designs.

In the Vulcan, Arnott and New Monarch hammers the ram is attached to the piston, while in the Cram, Clark and Goubert the cylinder itself forms the ram.

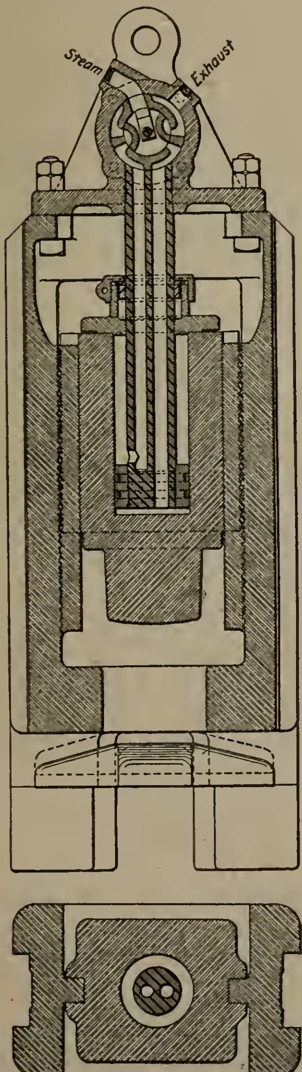


FIG. 1—THE GOUBERT STEAM HAMMER.

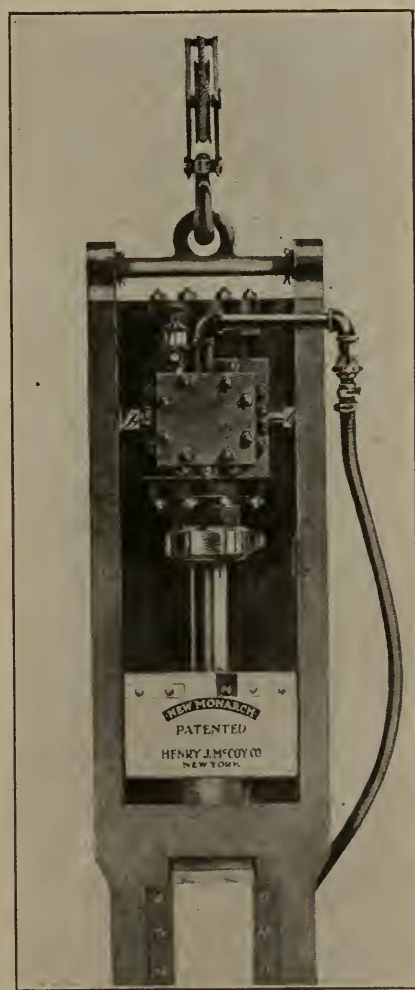


FIG. 2—THE NEW MONARCH STEAM HAMMER.

PILE-DRIVERS.

Figs. 4, 5 and 6 show a combination machine in which the boom of the derrick carries hanging leads. The illustrations indicate that it is fitted with a steam hammer. The following are its characteristic features: (a) The boom and leads may be easily lowered to clear overhead bridges and wires when it is necessary to get out of the way of trains. (b) Very

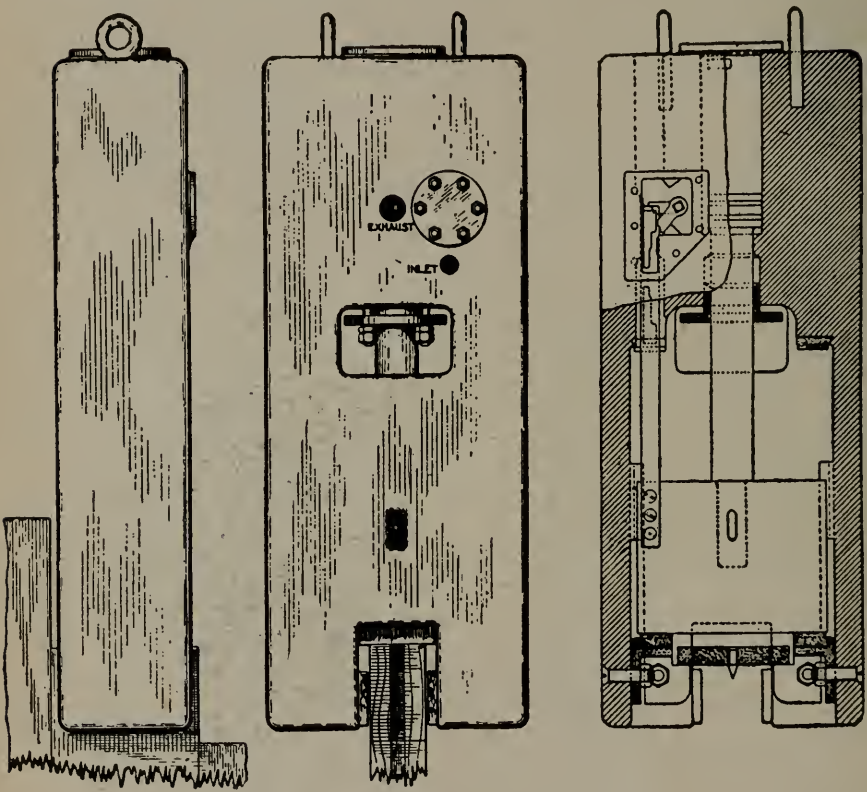


FIG. 3—THE ARNOTT STEAM HAMMER.

short leads can be used when required. (c) Piles may be driven to a considerable distance below grade without the use of a follower. The leads may hang down between the ties. (d) It can reach two bents of a trestle ahead of the machine. (e) It can be used for unloading and erection as well as for wrecking operations.

Figs. 7 and 8 illustrate another form of pile-driver with steam hammer, which has a reach of 17 ft. in front of the forward pair of truck wheels. Its principal features are: (a) The leads operate as a pendulum, allowing the piles to be driven on almost any batter. (b) The car and entire structure are of steel, thus giving greater strength. (c) The turn-

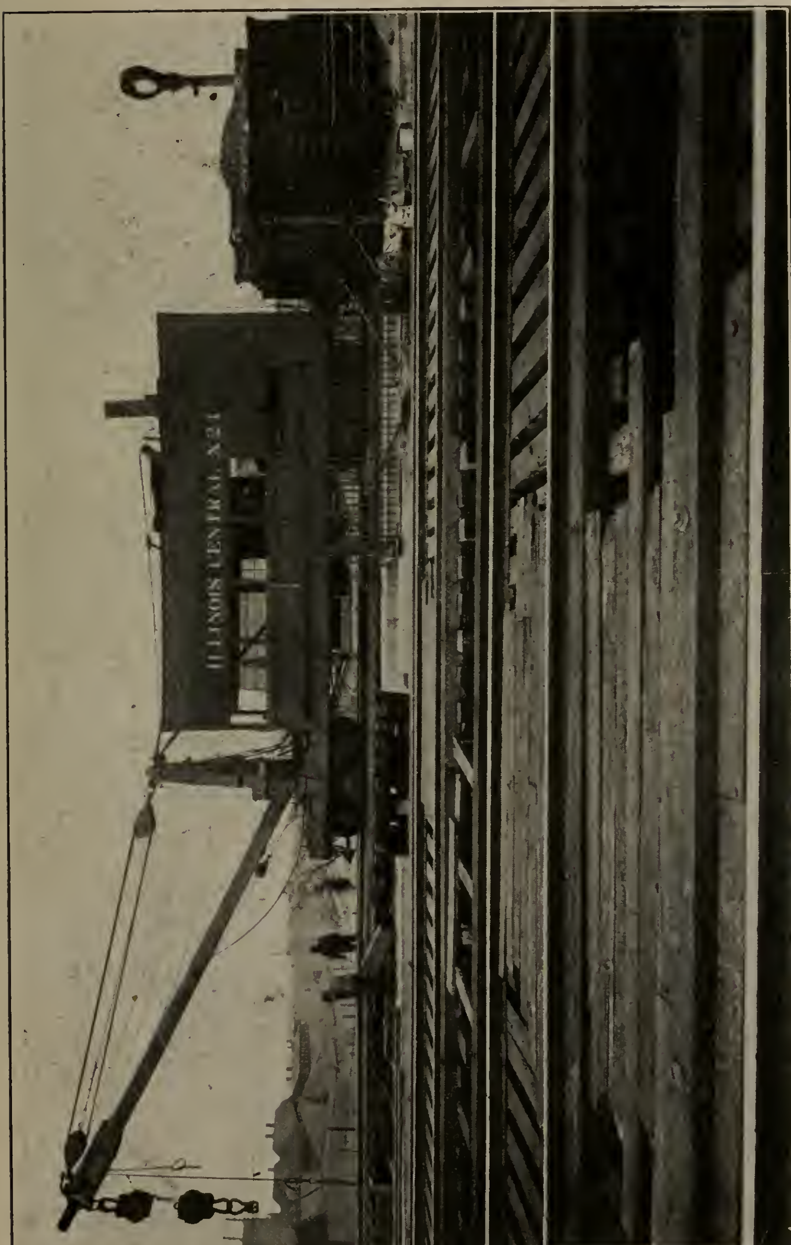


FIG. 4—COMBINATION DERRICK AND PILE-DRIVER—ILLINOIS CENTRAL RAILROAD.

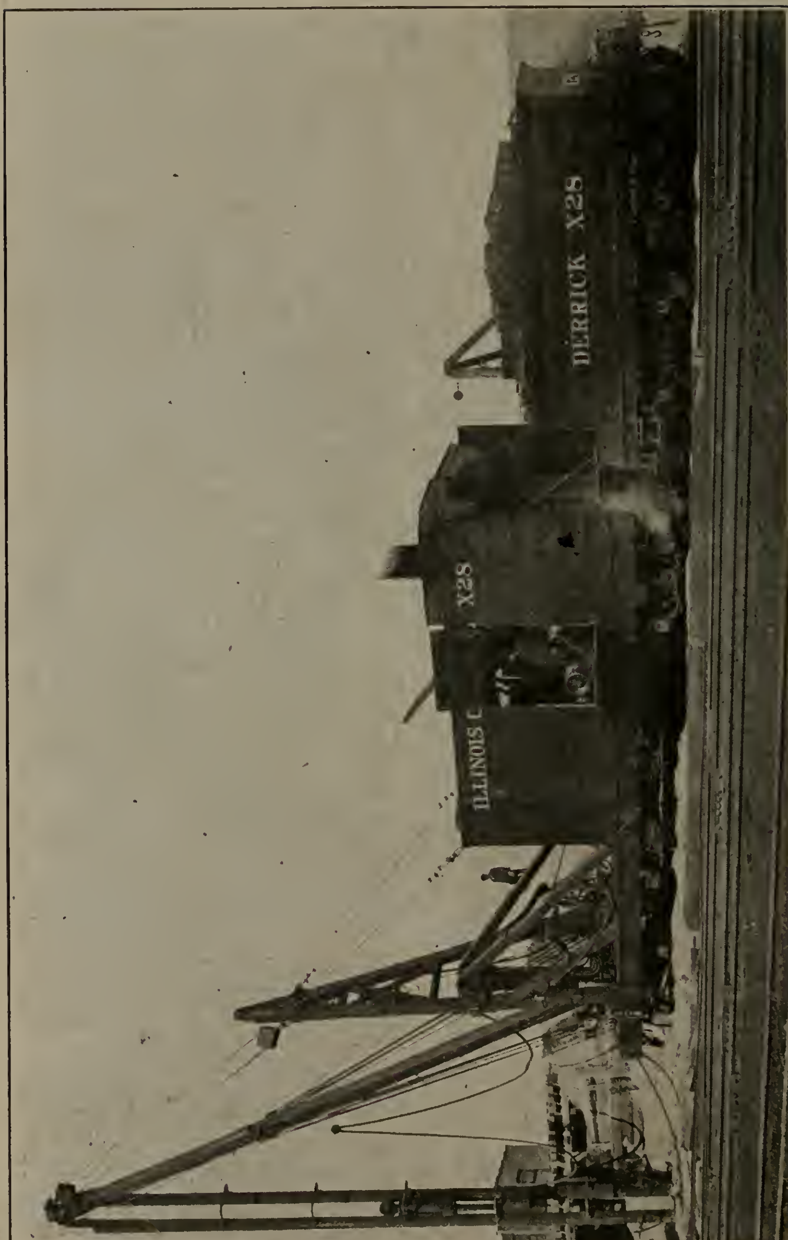


FIG. 5—COMBINATION DERRICK AND PILE-DRIVER—ILLINOIS CENTRAL RAILROAD.

table is independent of the engine room and can turn almost a complete circle. (d) The machine is self-propelling and can be handled without the extra cost of train service. (e) The boiler and engine are built directly

FIG. 6—COMBINATION DERRICK AND PILE-DRIVER— ILLINOIS CENTRAL RAILROAD.

upon the car and the engine is geared directly to the trucks for propelling the car. (f) The cast-iron counterweight on the back of the sills has a reduced projection in the side of the car when the leads are swung to drive outside of the track, and therefore more frequently avoids fouling an adjacent track or structure.

Figs. 9 and 10 show a type of driver fitted with a drop hammer, which was adopted about twelve years ago. It has an extension reach of about 19 ft. ahead of the forward pair of truck wheels on the car. Its main characteristics are: (a) Its leads can be tilted to drive piles on a batter. (b) The leads are counterbalanced by the hammer and are quickly raised and lowered. (c) The driver can be turned end for end on the car, and thus avoid turning the car on a turntable. (d) The car can be shipped in a train without an idler.

Figs. 11, 12, 13 and 14 show another form of all-steel pile-driver with steam hammer. The following are its principal characteristics: (a) Sufficient propelling power and speed to be entirely independent of the services of a locomotive. About 300 HP. can be transmitted continuously to the driving wheels, making it possible to haul 200 tons up a grade of 1.25 per cent. at 10 miles per hour, or to run any moderate train on level track at 25 miles per hour. (b) A boiler fixed to the car body and having nearly 800 sq. ft. of heating surface. (c) A powerful engine bolted to the car body and with direct gearing to the axles. (d) Reversibility by means of a turntable mounted underneath the car, by which the entire machine is lifted from the rails and turned end for end. (e) A strong truss and other parts to support the leads, enabling the machine to handle the heaviest concrete piles. (f) Long swinging leads raised and lowered by power.

DESIRABLE FEATURES OF A TRACK PILE-DRIVER.

(1) Steam hammer. To secure greater rapidity in driving and with less injury to the pile than that secured by the drop hammer.

(2) Water jet apparatus.

(3) Turntable allowing practically a complete rotation. In most cases the work can be done from either side, and in many of the remaining cases it is possible to foresee the nature of the work and to head the driver in the proper direction at the nearest "Y" or turntable. Sometimes, however, turning facilities may be far distant, or a pile-driver may be caught between two washouts when it becomes essential to be able to turn the machine to perform the work at both places.

(4) Swinging leads. The leads require an efficient rigging to permit driving piles with a batter in either direction. When driving across the track on such work as driving bents for an adjacent track, it is convenient to be able to drive with the leads not fully raised, so as to secure the proper batter.

(5) Self-propelling mechanism. The greater the tractive force and speed the more independent is the pile-driver from locomotive service. They should preferably be sufficient to dispense with a locomotive except for long hauls.

(6) Restricted projection on the side opposite the leads when swung across the track and without unnecessary weight.

(7) High-speed power device for raising the leads. On a main line it is frequently possible to drive only one or two piles before running to a siding. In some cases the character of this apparatus to raise the leads

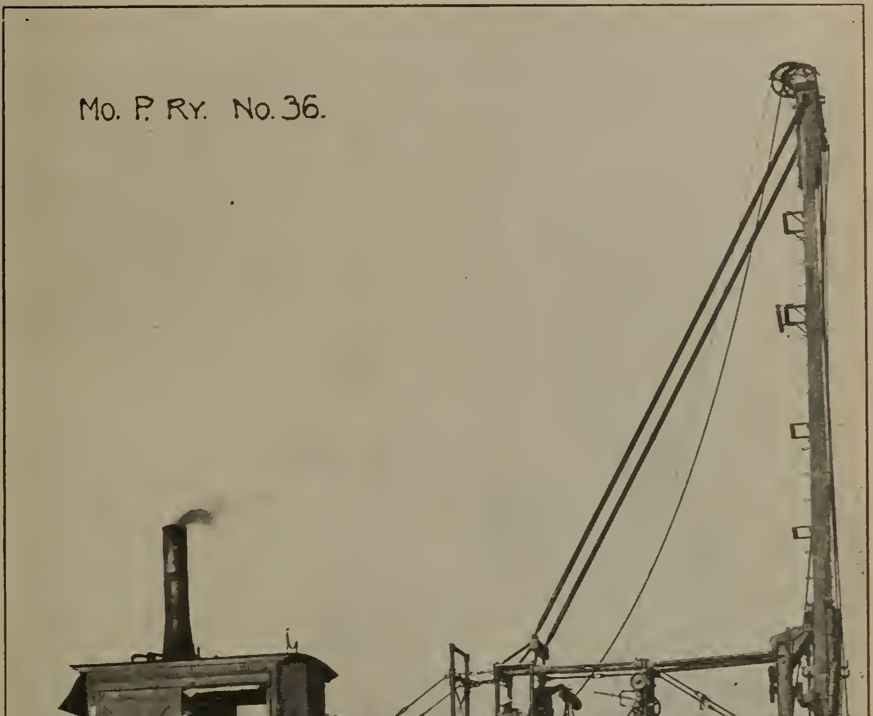


Fig. 7—Track Pile-Driver—Missouri Pacific Railway.

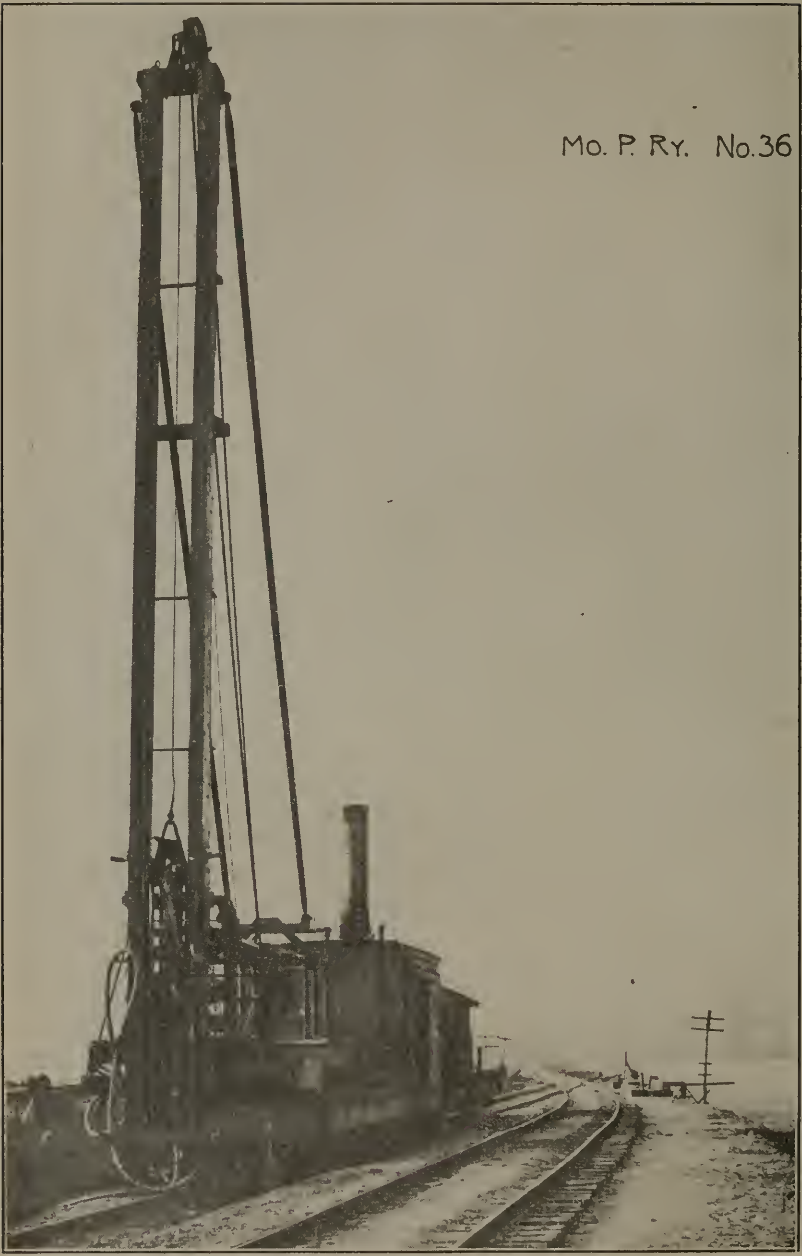


Fig. 8—Track Pile-Driver—Missouri Pacific Railway.

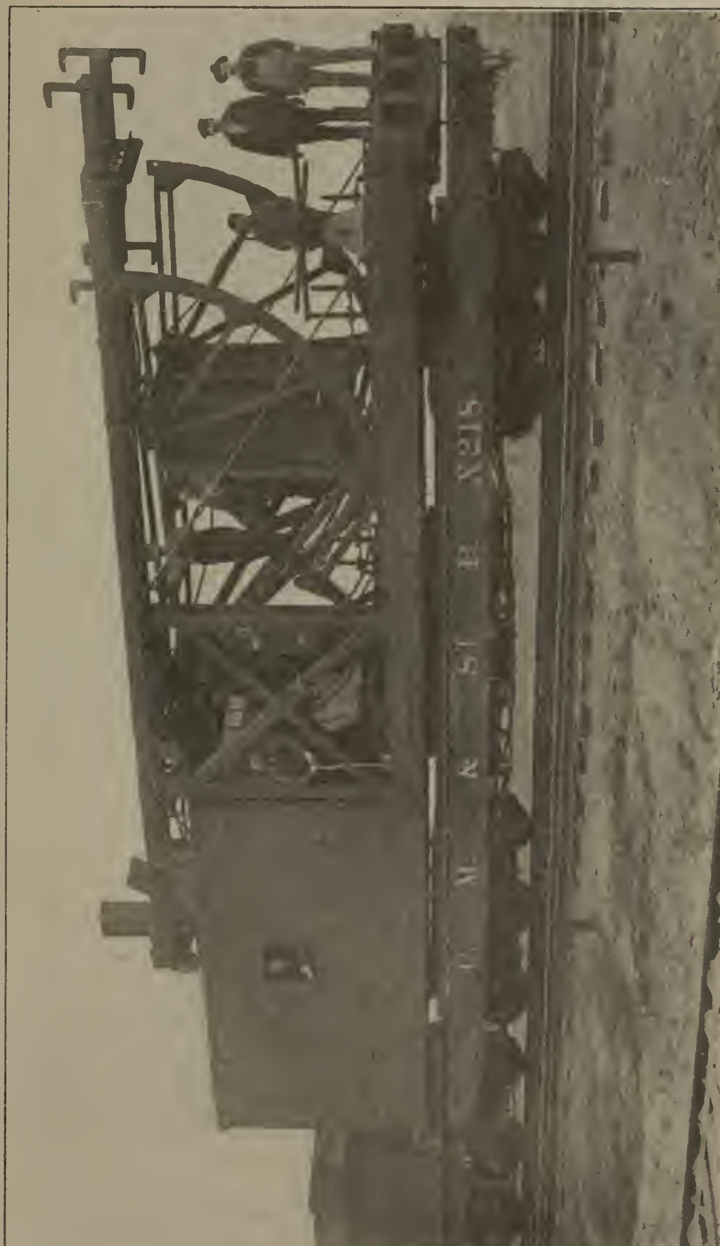


Fig. 9—Track Pile-Driver—Chicago, Milwaukee & St. Paul Railway

Fig. 10—Track Pile-Driver—Chicago, Milwaukee & St. Paul Railway.

FIG. 12—TRACK PILE-DRIVER—ATCHISON, TOPEKA & SANTA FE RAILWAY.

Fig. 13—Track Pile-Driver—Atchison, Topeka & Santa Fe Railway.

FIG. 11.

TRACK PILE-DRIVER.

FIG. 14—TRACK PILE-DRIVER—ATCHISON, TOPEKA & SANTA FE RAILWAY.

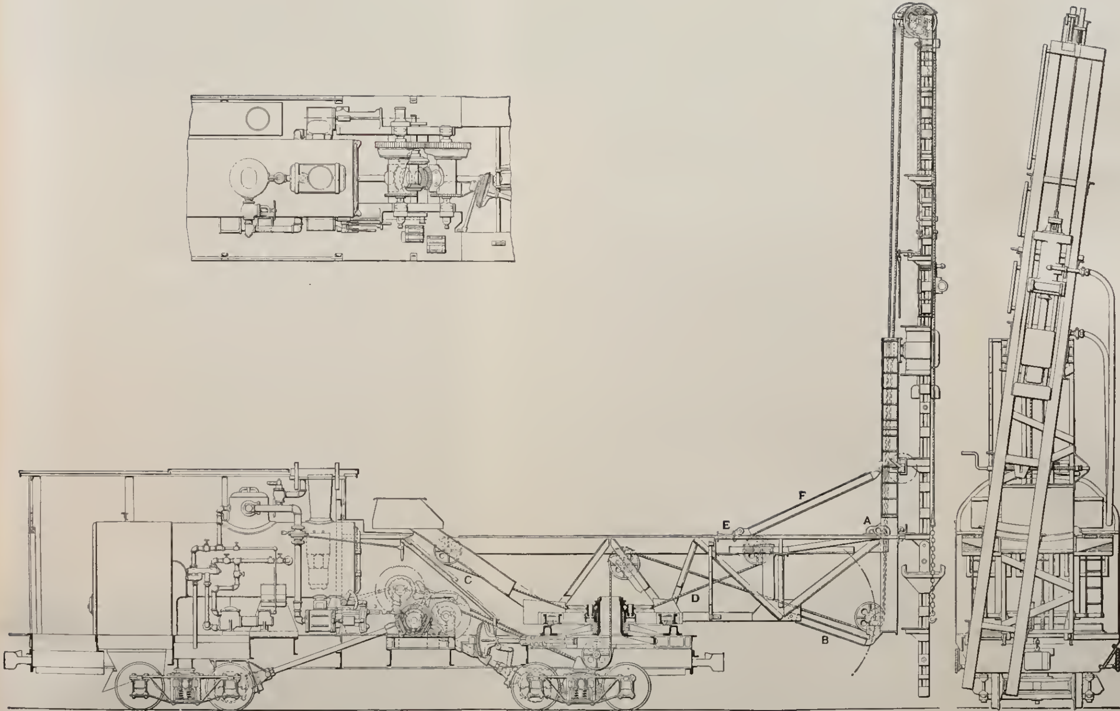


FIG. 11—TRACK PILE-DRIVER—ATCHISON, TOPEKA & SANTA FE RAILWAY

Fig. 14—Track Pile-Driver—Atchison, Topeka & Santa Fe Railway.

determines whether a single pile can be driven between trains or delaying a train.

(8) Adequate overhang. To enable machines to drive piles as far ahead of the leading wheels and as far sidewise as possible. On work for double-tracking the sidewise reach should be sufficient to drive a bent on the new track from a position on the old track.

(9) Facilities for driving below the track.

(10) Ability to shift the hammer when the leads are down.

(11) No obstructions in the view of the engineman and niggerhead operator.

(12) Length of leads. To accommodate the longest piles practicable.

(13) Strength and rigidity of supports for leads and hammer. They should be adequate to handle the hammer and the heaviest wooden pile without damage. It is now becoming important to be able to handle concrete piles.

(14) Stability. The driver, while standing on its own wheels, without any jacks or special supports, should be able to pick up and drive a pile in any position within its reach.

(15) Flush ends. For convenience of transportation in freight trains, no part projecting beyond the drawheads. Otherwise an idler is required, which then may be used as a tool car.

(16) No lengths of steam hose that might be replaced by pipe.

SHEET PILES.

In Circular 123, issued in July, 1909, the Committee requested from the members of the Association, data in regard to the use of Sheet Piles (Proceedings, Vol. 1, p. 216).

Only 15 replies were received and it would appear that the term "sheet piles" was generally understood to refer to wooden rather than steel piling.

Of the 12 replies on wooden sheet piling, nine reported the use of triple lap, or Wakefield sheeting (Proceedings, Vol. 10, p. 569). The other three reported tongue and groove, or square-edged timber for special use. The sheeting was used in lengths up to 40 ft. and the planks were of either 2 in. or 3 in. thickness.

The piles were driven by mauls for lengths of about 12 ft., and for greater lengths drop hammers, from 1,800 lbs. to 3,000 lbs. weight were used.

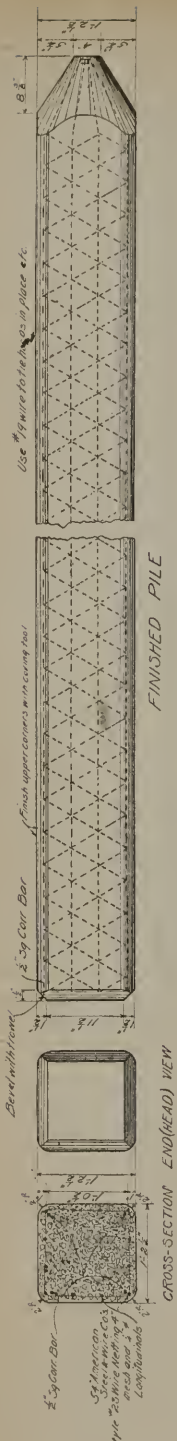
The area of the enclosed space varied from 500 to 18,500 sq. ft. In regard to the depth of water penetration and excavation, the replies were rather indefinite, but it appears that generally the piles were driven to a maximum of about 8 ft. below the intended excavation, while in one case the excavation was carried to the lower ends of the sheeting.

The material penetrated was generally sand and mud, though in two instances driving in gravel was reported.

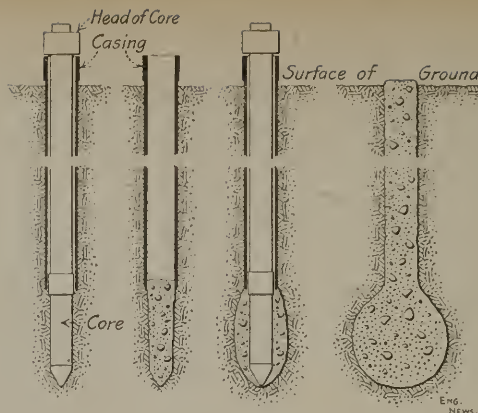
In most cases the sheeting was well braced with wales and cross struts, but in one operation no bracing was used for 6-in. piling in 10 ft. of water. In 30 ft. of water an area 43 ft. by 100 ft. was divided into 15-ft. squares, using 8-in. by 16-in. timbers for both wales and struts.

PELESTAL PILE—MACARTHUR CONCRETE PILE FOUNDATION COMPANY.

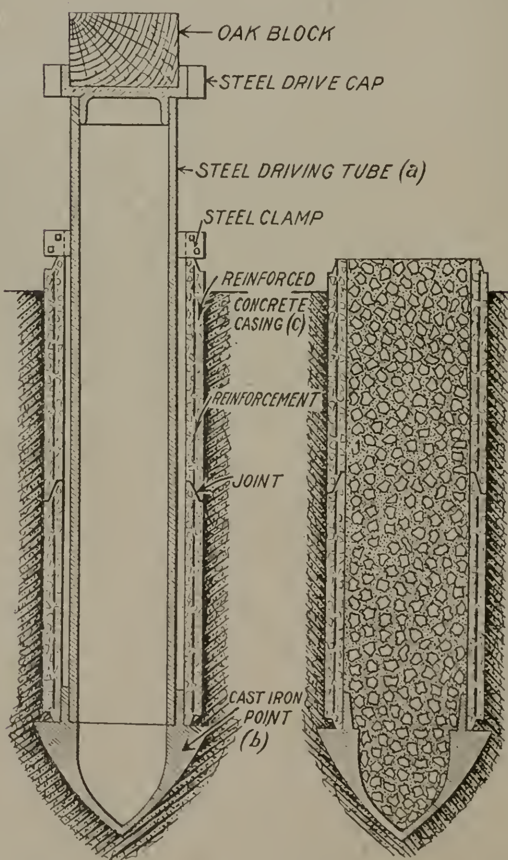
The following report on the strength required in sheet piling is presented as information and for discussion. The Committee urge that the members furnish the results of their use of steel sheet piling, with particular reference to the pressures resisted by the piling.



Reinforced Concrete Pile—C., B. & Q. R. R.



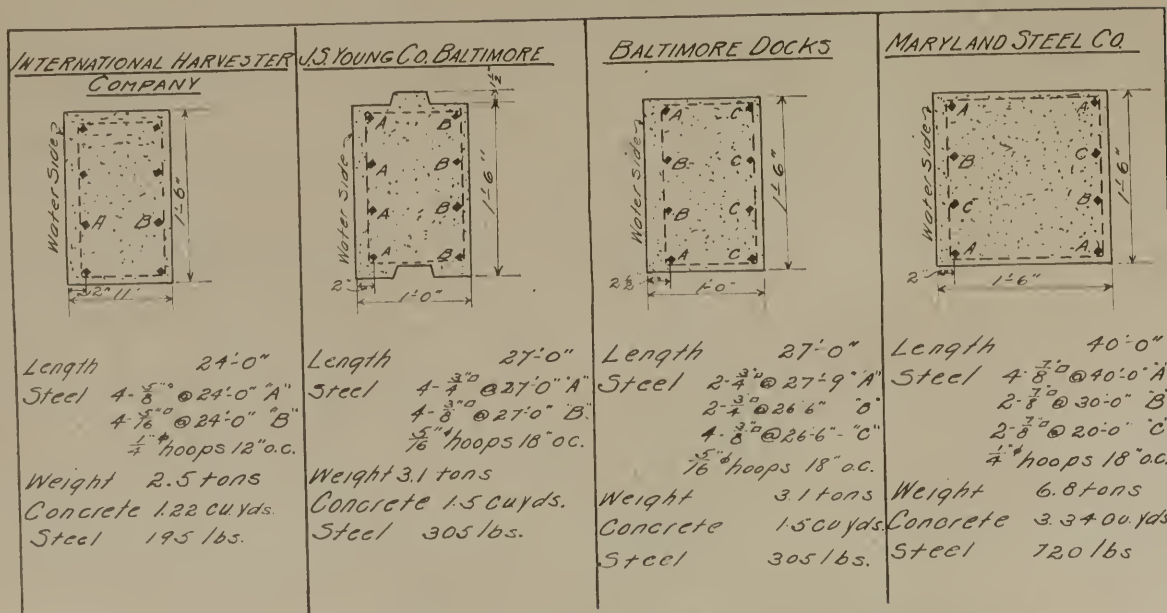
Pedestal Pile.



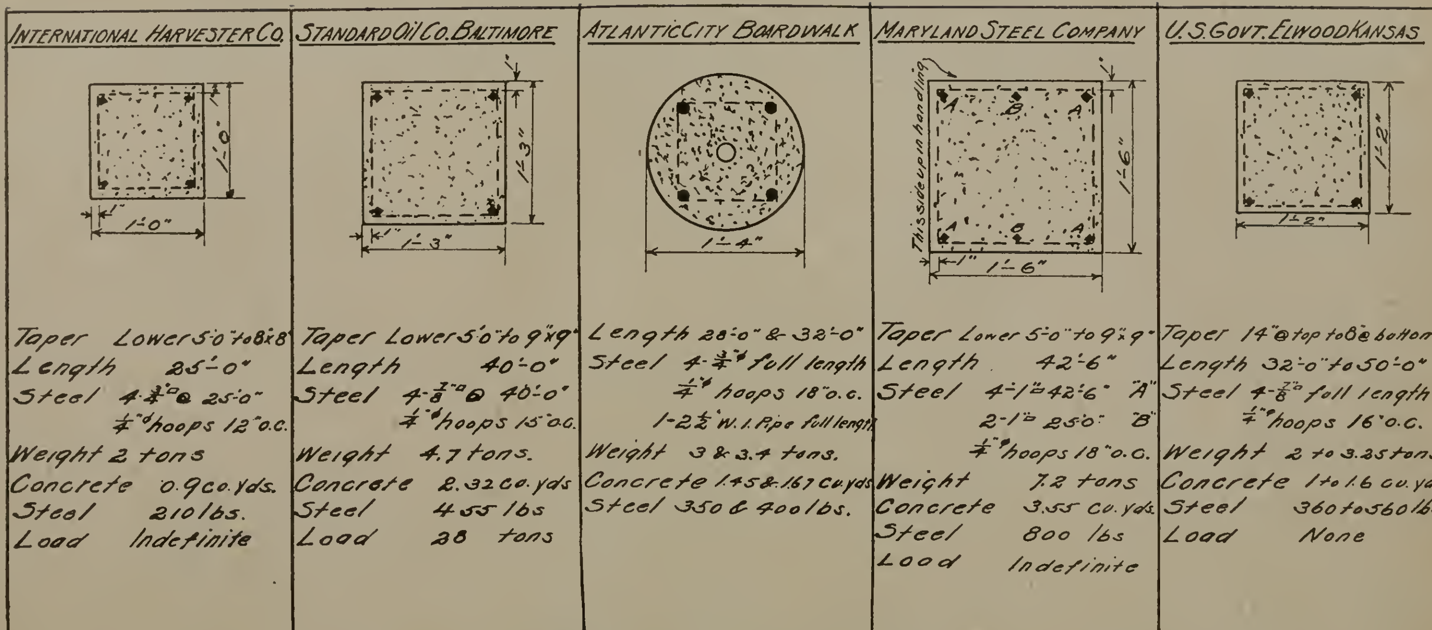
Concrete casings driven to refusal

Finished Pile

Pile with Reinforced Concrete Casing.



Bearing and Sheet Piles—Raymond Concrete Pile Company.



BEARING AND SHEET PILES—RAYMOND CONCRETE PILE COMPANY.

Appendix D.

THE STRENGTH OF SHEET PILING.

The magnitude of the stresses in sheet piling, due to bending, depends upon the kind of material retained by it. Sheet piling is generally held in place by a wale at the top, one at or near the bottom of the excavated trench or area, and sometimes by one or more at intermediate points.

In deriving the following formulas all weights are expressed in pounds per cubic foot, all distances in feet, and all bending moments in pound-feet. A vertical strip of piling 1 ft. wide is considered for the sake of convenience.

1. *Pressure due to water.* Let the upper wale be assumed at the water surface and the lower wale at the bottom of the excavation, or at a distance D below the surface of the water, both wales being properly braced. By the methods of mechanics the greatest bending moment occurs at a distance 0.577 D below the surface, if the piling be treated as a simple beam. This point is farther from the middle of the unsupported length than in any other case where one or more additional wales are employed. The eccentricity may, however, be regarded as offset by the partial continuity of the lower end which penetrates the soil, and thus the greatest bending moment may conveniently be taken at the middle of the unsupported depth. The value of the greatest bending moment is 3.91 D^3, the weight of a cubic foot of water being taken as 62.5 pounds. If an additional wale be located at a height C above the bottom one, the greatest bending moment between them is 3.91 $(2\,C^2D - C^3)$. In case both the top and intermediate wales be omitted the bending moment at the bottom is 10.42 D^3. If the fluid material retained by the sheet piling is heavier than water the pressures and bending moments are proportionally increased.

2. *Pressure due to dry sand.* According to Coulomb's theory the horizontal pressure expressed in pounds per square foot for material which assumes a slope of 1.5 to 1 is $W\ H\ \tan^2\ (45° - \frac{1}{2}R)$, in which W is the weight per cubic foot of the material, H the depth at which the pressure occurs, and R the angle of repose expressed in degrees. This indicates that the pressure varies directly with the depth as in hydrostatic pressure, but that the unit weight of the material is $W\ \tan^2\ (45° - \frac{1}{2}R)$ instead of W. In the material under consideration it is observed that the trench may be excavated a foot or more below the bottom of sheeting without causing any flow, and hence it may be assumed that the pressure is zero at the bottom as well as at the top.

It has also been observed that the center of pressure against sheet piling is not at one-third of the depth from the bottom, but more nearly two-thirds of the depth (see Earth Pressure and Bracing, by J. C. Meem, in Trans. Am. Soc. C. E., Vol. 60, and the accompanying extended discussion). It seems, therefore, that the angle of repose for any given material is not constant but varies in some manner, although not directly as the depth. In conformity with these facts R may be taken equal to 90° $(H/D)^{0.6}$. The exponent 0.6 is based on the result of observations.

For material having an angle of repose of 33° 40′, which corresponds to a slope of 1.5 to 1, Coulomb's formula gives a horizontal pressure equal to 0.12 $W\ D^2$, and the overturning moment about the base of 0.04 $W\ D^3$, which is claimed by Sir Benjamin Baker to be double the true value. From the results of Trautwine's experiments on overturning moment, due to dry sand, it is computed to be 0.019 $W\ D^3$. By plotting the horizontal pressures derived from the values $W\ H \tan^2 [45° - 45° \ (H/D)^{0.6}]$ for different depths, the total pressure for dry sand is found to be 0.029 $W\ D^2$, and the center of pressure is approximately two-thirds of the depth of the excavation from the base, making the overturning moment 0.019 $W\ D^3$, as before.

For sheet piling resisting the pressure of dry sand when held in position by wales at the top and bottom of the excavation, the greatest bending moment occurs at a distance 0.43 D from the top and equals 0.0045 $W\ D^3$. When an intermediate wale is placed at a height C above that at the bottom, the bending moment becomes 0.0045 $W\ C^2\ D$.

3. *Pressure due to wet slipping material.* There remains to be considered the wet slipping material which exerts a much greater pressure than dry sand but a smaller pressure than water. Such material produces a considerable pressure at the bottom of the excavation. To meet this condition it may be assumed that the depth at which the horizontal pressure becomes zero is 2 D instead of D. When this change is made in the previous value for horizontal pressure the results agree closely with those of observation. The total pressure above the bottom of the excavation is 0.08 $W\ D^2$, and the center of pressure is at $\frac{1}{2}$ D. The overturning moment about the base is then 0.04 $W\ D^3$.

The greatest bending moment on sheet piling supported at the top and bottom only and retaining wet slipping material is 0.013 $W\ D^3$ and occurs at half depth. When an intermediate support is placed at a distance C above the bottom the bending movement is 0.013 $W\ C^2\ D$.

The above formulas are presented with the hope that all members of the Association who have obtained definite results by experience will contribute them either in the form of discussion or directly to the Committee for further study. It may be added that experimental investigations are being made by Professor A. P. Mills in the laboratory of the College of Civil Engineering at Cornell University.

Appendix E.

MECHANICAL PROTECTION OF PILES AGAINST MARINE WOOD BORERS.

Various methods of mechanical protection of piles against marine wood borers are described in an abstract from U. S. Forest Circular 128, printed in Appendix E of the report of this Committee (see Proceedings, 1910, Vol. 11, pp. 200-216), in sufficient detail to give a good general idea of the methods employed. The replies to questions relating to this matter in Circular 123, which was sent out by this Committee, were not large in number and added nothing to the information given in the abstract of the Forest Service Circular. The general practice seems to be to rely on creosote treatment.

The cost and efficiency of the methods described are not discussed in the abstract mentioned or in any of the replies to Circular 123 of this Committee. An effort has therefore been made during the past year to obtain information on these points. With this end in view, letters were addressed to the chief engineers of some of the lines having terminals on the Atlantic and Gulf coasts. The replies to these letters indicate that only two companies have employed mechanical protection for piling.

On the Louisville & Nashville Railroad the methods most extensively used are:

(1) Encasing the piles in a rich mixture of Portland cement and sand, or Portland cement, sand and fine gravel filled between the piles, and removable flasks of wood, or wood and iron.

(2) Filling sand between the piles and vitrified clay pipe slipped over the tops of the piles (after heads of piles have been freed) and left in that position, pitch being mixed with the sand at the top.

The cost of the first method is reported to have been in the neighborhood of $1.50, and of the second about $1.10 per linear foot of pile protected. Better results were obtained from the use of Portland cement concrete than from a mixture of cement and sand.

The mortar or concrete filled between the flask and the pile mixed with the mud at the bottom to such an extent that the lower part of the protection often broke off. It was found impossible to overcome this entirely. A more serious fault was the cracking and breaking off of the upper part of the encasement. The second method was adopted to avoid these weaknesses. It is reported that this method gives fairly good results, and has been in general use on the Louisville & Nashville Railroad since 1893. When a section below the top fails it is removed and the upper sections are lowered, after which a new section is formed at the top by fastening cast iron casings (which come in two halves) around the pile and filling as before.

On the Louisville & Nashville Railroad the protection was applied to creosoted piles, which Mr. Courtenay, Chief Engineer, states had been standing in sea water for a sufficient length of time to be no longer immune from the teredo.

In 1902, the Port Arthur Canal & Dock Company, a subsidiary of the Kansas City Southern Railway Company, protected a large number of untreated pine piles at Port Arthur, Tex., by placing a 24-in. sewer pipe around the piles and filling a mixture composed of one part Portland cement and one part sand between the piles and the sewer pipe. Part of the decks of the wharves were renewed at the same time. In case the pile to be treated came under a portion of the deck that was renewed, the sewer pipe was dropped over the head of the pile. In case the cap was not displaced, the sewer pipe was cut into halves longitudinally, and after being placed around the pile was fastened together by means of wire. The protection extended from a foot or two below mud line to a little above high tide.

On account of the burning of Division offices the cost of this work is not available. Complete protection was afforded the piles against the teredo, but these piles have decayed above the water line to such an extent that it will soon be necessary to replace them in whole or in part.

AMENDMENTS.

Amend clause 4, Principles of Practice for Pile Driving, to read as follows:

"(4) The proper diameter and length of pile and the method of driving depend upon the result of previous explorations and the purposes for which they are intended."

Amend clause 8 to read as follows:

"(8) In general, the water jet should not be attached to the pile, but handled separately."

Amend clause 13 to read as follows:

"(13) There is danger from overdriving when the hammer begins to bounce. Overdriving is also indicated by the bending, kicking or staggering of the pile."

Amend clause 15 to read as follows:

"(15) The weight or drop of the hammer should be proportioned to the weight of the pile, as well as to the character of the soil to be penetrated."

Amend clause 26 to read as follows:

"(26) Timber piles may be advantageously pointed, in some cases, to a 4-in. or 6-in. square at the end."

Amend clause 27 to read as follows:

"(27) Piles should not be pointed when driven into soft material."

DISCUSSION.

(The report on Wooden Bridges and Trestles was presented by the chairman, Mr. Henry S. Jacoby, Professor of Bridge Engineering, Cornell University.)

Prof. Henry S. Jacoby:—The first of the conclusions relates to the pile record form, which is given in Appendix A. It will be recalled that last year a considerable number of forms for pile records, as used by various railroads, were published, and after the discussion of those forms, the one recommended for adoption was drawn up by the Sub-Committee.

(Prof. Jacoby then read conclusion 1.)

"(1) That the Pile Record Form be adopted as a standard."

Mr. J. P. Snow (Boston & Maine):—I would like to ask the Chairman what the column headed "Cut-off" means?

Prof. Jacoby:—That relates to the length which is cut off after the pile is driven.

The President:—If there is no objection, the recommendation of the Committee will be accepted.

Prof. Jacoby:—Conclusion 2 is as follows:

"(2) That the Principles of Practice for Pile Driving be adopted."

These principles are given in Appendix B. The attempt has been made to formulate as briefly and succinctly as possible the fundamental principles relating to this subject, but as no similar effort has been made previously, the Committee feels that the result is doubtless not perfect, but it is hoped to give the subject further consideration from year to year and to make such revisions as additional information may require. In this connection the Committee desires to thank those who have taken part in the discussion, so far as printed in Bulletin 131, because the records of such experience and observation are necessary to formulate additional principles.

The President:—The Secretary will read paragraphs under "Pile Driving—Principles of Practice."

The Secretary:—"(1) A thorough exploration of the soil by borings, or preliminary test piles, is the most important prerequisite to the design and construction of pile foundations.

"(2) The cost of exploration is frequently less than that otherwise required merely to revise the plans of the structures involved, without considering the unnecessary cost of the structures due to lack of information.

"(3) Where adequate exploration is omitted, it may result in the entire loss of the structure, or in greatly increased cost."

Mr. H. A. Lloyd (Erie):—Does this all pertain to new structures and not to rebuilding of old structures?

Prof. Jacoby:—In rebuilding old structures, where the proper information is not at hand, of course these principles will apply, but it is true that most of them will apply more particularly to new rather than to old structures. It is assumed, if the original work was done properly that the piles in the old structure will serve the purpose of test piles for the new, or will give other information that may be of service.

The Secretary:—"(4) The proper diameter and length of pile, and the method of driving, depend upon the result of previous exploration."

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I move that we add to that, "and the purpose for which they are intended."

Prof. Jacoby:—The Committee accepts that suggestion.

Mr. C. A. Morse (Santa Fe):—I would ask why, if this is for railroad purposes, and I understand we usually have a specification—

The President:—The Committee states that this does not intend to affect the specifications in any manner.

Prof. Jacoby:—The specifications give certain diameters as related to certain length, but, while in some cases the length only needs to be considered, there may be other cases in which, for example, long slender piles are undesirable and special conditions require a more careful selection of piles than would otherwise be made. It seemed best, therefore, to include all of these elements in the general statement.

The Secretary:—"(5) Where the soil consists wholly or chiefly of sand, the conditions are most favorable to the use of the water jet.

"(6) In harder soils containing gravel the use of the jet may be advantageous, provided sufficient volume and pressure be provided.

"(7) In clay it may be economical to bore several holes in the soil with the aid of the jet before driving the pile, thus securing the accurate location of the pile, and its lubrication while being driven."

Mr. W. H. Courtenay (Louisville & Nashville):—I think exception might reasonably be taken to clause 7. In the practical operation of driving piles it is quite an expensive matter to get together the apparatus for the jet. In ordinary clay there is no difficulty in driving a pile sufficiently without jetting. A jet does not work very well in clay, and unless the clay is mixed with a very large proportion of sand, it is doubtful if much would be accomplished by boring holes with a jet for the purpose of placing piles. For the benefit of the Association I will say that in my own experience jets have been used for the purpose of making holes to put piles in for the sole reason that the height of base of rail above the ground was too small to permit placing 70 ft. piles in 50 ft. leads; we, therefore, had to make holes to put the piles in to get them in the leads, so the hammer could strike them. For that purpose, the cheapest expedient we could devise was to jet holes of sufficient depth to place the piles for driving. In general practice, in clay, I do not think this Committee should go on record as saying it may be economical to bore several holes in the soil with the aid of the jet before driving the piles for the purpose of securing accurate location of the piles, or for the purpose of lubricating the piles going down. I do not believe that would be necessary in order to satisfactorily drive piles in clay soil.

Mr. L. J. Hotchkiss (Chicago, Burlington & Quincy):—The paragraph in question refers more particularly to the driving of concrete piles. I have seen several cases myself where it was quite difficult to drive the piles without the jet, without battering up the heads of the piles, but by using the jet as mentioned in this paragraph, the piles went down without any particular difficulty. They went straight and they were gotten down to a penetration that could not be reached without the use of the jet. This particular method would only apply in certain kinds of clay—clay with a certain amount of sand or loam. If it were a very stiff clay, the jet would not penetrate. I know since we have been driving concrete piles on the Chicago, Burlington & Quincy we have gotten into the use of the jet to a greater extent than ever before, and we can get piles down more economically and quickly with the use of the jet than in any other way. We have not used it very much in driving wooden piles, but in concrete piles we find it almost indispensible, and practically all of our concrete pile-driving outfits are equipped with jetting apparatus.

Mr. W. F. Steffens (Boston & Albany):—The Committee has tied down clause 7 to boring holes with the water jet. It is conceivable that another case may arise. There is a peculiar quality of soil in North Carolina, familiar to some of the members from the Middle South, through which it is almost impossible to drive piles even with metal points. In that soil it seems that the use of an earth or clay auger would be indicated, as the material could then be removed, allowing a cavity into which the pile could be dropped, and then be seated, perhaps, with the hammer. I have in mind a case where the use of the jet was advised as a lubricating method in clay soil. The auger will sometimes produce a result the Committee is seeking to produce entirely by the water jet.

The President:—Do you recommend amending clause 7 by the addition of your suggestion?

Mr. Steffens:—I will offer that to the Committee as a suggestion.

Mr. L. J. Hotchkiss:—It seems to me, in such an important matter as that to which our attention has been called (and another example came to the attention of the Committee after this report was placed in form), that that experience is of sufficient importance to be considered by the Committee, and later to bring in some additional statement that will apply particularly to such a case. The attempt is here made to separate various items, and then an engineer ought to use his intelligence to see what are the particular conditions; that is, each of these principles will apply to the conditions he has to deal with, and that is why in the beginning so much emphasis has been placed upon the matter of finding out what the conditions are, by previous explorations.

Instead of amending this, I would prefer that the matter go to the Committee and that they would bring in a supplementary statement next year.

The President:—Is that satisfactory, Mr. Steffens?

Mr. Steffens:—I think that would be more desirable.

Mr. Snow:—It seems to me that we could cure that by an amendment which I am going to suggest, and the Committee can accept it or not, as they please. Why should not we say, with the aid of the jet or other means? Insert the words "or other means" between jet and "before." I think that would cover not only the case mentioned by Mr. Steffens, but other schemes that might be thought of.

Mr. Steffens:—It must not be overlooked that the last few words read, "and its lubrication while being driven."

Mr. A. F. Robinson (Santa Fe):—Is that supposed to cover concrete reinforced piles? Would it not be well to add a note stating that the conclusion applies especially to reinforced concrete piling?

Mr. L. J. Hotchkiss:—The experience of one railroad, in rather extensive pile driving, where concrete piles were not employed in this same method would justify the absence of any limitation; but the Committee has had in mind all through this work that these principles should be so stated as to apply to one or the other, or both, as the case may be, so that they should be considered in connection with any special work that is done.

The President:—Mr. Snow, the Committee feels that they would rather have this matter referred back to them than to have the amendment made now. Do you make the motion that it be amended now?

Mr. Snow:—No.

The Secretary:—"(8) The water jet should not be attached to the pile, but handled separately."

Mr. Courtenay:—I think that is a little too sweeping. We are now driving on the Louisville & Nashville Railroad piles 100 ft. long, through 55 ft. of water. The bottom is sand. We get the piles down with the aid of a jet very satisfactorily to a depth of about ten ft. and then we strike a stratum of hard material, and we have great difficulty in getting it through. The current is exceedingly strong there—it is a tidal current, first north and then south, depending on whether the tide is running in or out. In the case which I cite, I think it would be impossible to jet the piles without the jet being attached to the piles. The current is so swift in the water that a deep-sea diver cannot hold himself to the pile without being practically chained to it. In many places, where there is occasion to jet piles down, the jet pipe must necessarily be attached to the pile. Otherwise the two would become so widely separated the jet would do no good.

Mr. F. A. Bagg (Fonda, Johnstown & Gloversville):—It was the practice some years ago on the construction of Government jetties to attach the galvanized iron pipe, one to either side of the pile, and a flexible rubber hose was connected from the top of the pipe to the pump. That seemed to be the only successful way in which they could put down piles in sand. I do not know that that practice has changed, but it may be that the Committee is thoroughly informed on the subject. I think the Government developed the practice by first somewhat awkwardly excavating a hole by a jet that was separated from the pile, but afterwards it was necessary to attach the jet to the side of the pile and let it go down with the pile.

Mr. L. J. Hotchkiss:—My personal experience with the jet attached to the pile has been that the jet became wedged fast and could not be pulled out. I remember in one case the jet was pulled in two trying to get it out. It occurs to me that Mr. Courtenay's idea may be simply to keep the jet near the pile, that it is not rigidly attached to the pile.

Mr. Courtenay:—We use wrought pipe attached to the pile with staples. It would be impossible, in 50 ft. of water, with a swift current, to sink a pile otherwise with a jet than by attaching the jet and the jet pipe to the pile.

Mr. L. J. Hotchkiss:—I thought you simply held it up near the pile, allowing freedom of motion with the jet.

Mr. Courtenay:—Yes; we attached the jet which is a pipe flattened down to the side of the pile.

Mr. L. J. Hotchkiss:—It was not rigidly attached to the pile?

Mr. Courtenay:—Our plan was, when the pile was down, to withdraw the pipe.

Mr. L. J. Hotchkiss:—If we could say in this paragraph under consideration that the water jet should not be rigidly attached to the pile, I think that might meet the conditions.

Mr. Courtenay:—I think it would really be best, as this matter is general, simply to omit clause 8.

Mr. Steffens:—Clause 8 only covers the case of wooden piles and concrete piles as previously suggested by another member. I should like to know from the Committee what would happen in the case of a concrete pile, cast with the jet hole in the middle, as many are cast—would they attach the jet on the outside or attach it to the pile?

Prof. Jacoby:—I think the general experience in recent years by those who have done a great deal of pile-driving, is that there is more difficulty with clogging the jet when it is a part of the pile than in any other case, and certainly the prevailing practice at present is to handle the jet separately. A special case came to the attention of the Committee recently, and which will be considered in a later report, where the conditions are radically different because the concrete pile itself performs the functions of the hammer, and it is consequently advantageous for the jet to form a part of the pile.

The President:—Mr. Courtenay, will you make a motion to eliminate clause 8?

Mr. Courtenay:—I would make a motion to modify clause 8 to this extent, so as to read, "water jet should not be attached to the pile, and should be handled separately when piles are driven in dry ground, but not when they are driven through water."

Prof. Jacoby:—Would it meet Mr. Courtenay's idea to say "in general, the water jet should not be attached to the pile, but handled separately?"

Mr. Courtenay:—I have no objection to that, but I think it is not applicable to all cases.

Prof. Jacoby:—The Committee will insert the words "in general."

The Secretary:—"(9) Two jets will often succeed where one fails, in special cases a third jet extending a part of the depth aids materially in keeping loose the material around the pile.

"(10) Where the material is of such a porous character that the water from the jets may be dissipated and fail to come up in the immedate vicinity of the pile, the utility of the jet is uncertain, except for a part of the penetration.

"(11) A steam or drop hammer should be used in connection with the water jet, and used to test the final rate of penetration.

"(12) The use of the water jet is one of the most effective means of avoiding injury to piles by overdriving.

"(13) There is danger from overdriving when the hammer begins to bounce, provided the head of the pile is not broomed. Overdriving is also indicated by the bending, kicking or staggering of the pile."

Mr. Courtenay:—I would suggest the elimination of the words "provided the head of the pile is not broomed." Piles may be damaged by overdriving and are damaged by overdriving when heads are broomed as well as otherwise.

Prof. Jacoby:—The idea expressed is that if the head is broomed, which it will be under continuous driving for some time, the effect of the hammer is lost in large part and then the bouncing of the hammer will not indicate any injury in another part of the pile. If the head of the pile is in fair condition, and you find the hammer bouncing, it indicates that some portion of the pile which is not visible, is being injured, and it is very important to act accordingly. Of course it is true, in many cases, that the brooming of the head of the pile also indicates that the driving should be stopped, but the rapidity with which the brooming develops and other indications should show to the one in charge what the conditions really are.

Mr. Courtenay:—I think those words are misleading. I have seen piles absolutely broken when their heads were broomed, and as a general proposition I would say that when the heads are badly broomed, you may expect more damage has been done to the piles than when the heads are not broomed. On driving piles on several occasions I have had to take them out. I found them badly broken in a variety of ways, and the heads were broomed.

A Member:—It is almost the universal custom in driving piles now to use a cap, and when the cap is used, there is no brooming.

Mr. Courtenay:—I beg to say that we drive many thousands of piles a year and we do not cap them; we ring them, or band them.

Mr. Jos. O. Osgood (Central of New Jersey):—What brooming is referred to, the brooming of the small end of the pile, or the head?

The President:—The head of the pile. It definitely states the head of the pile. The Committee is not willing, Mr. Courtenay, to accept the amendment you suggest. Do you offer a motion?

Mr. Courtenay:—In that event I offer the motion that in clause 13 the words, "provided the head of the pile is not broomed," be eliminated.

(The motion carried.)

The Secretary:—"(14) The brooming of the head of a pile dissipates a part, and in some cases all, of the energy due to the fall of the hammer.

"(15) The weight of the hammer should be proportioned to the weight of the pile, as well as to the character of the soil to be penetrated."

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—Referring to clause 15. I do not see how we can readjust the weight of the hammer every time we have a different length of pile. I suggest that we modify the clause to read, "the weight or drop of the hammer."

The President:—That is satisfactory to the Committee.

The Secretary:—"(16) The steam hammer is more effective than the drop hammer in securing the pentration of a pile without injury, because of the shorter interval between blows.

"(17) Where shock to surrounding material is apt to prove detrimental to the structure, the steam hammer should always be used instead of the drop hammer. This is especially true in the case of sheet piling, which is intended to prevent the passage of water. In some cases also the jet should not be used.

"(18) In general, the resistance of piles, penetrating soft material, which depend solely upon skin friction, is materially increased after a period of rest. This period may be as short as fifteen minutes, and rarely exceeds twelve hours.

"(19) In tidal waters the resistance of a pile driven at low tide is increased at high tide on account of the extra compression of the soil.

"(20) Where a pile penetrates muck or soft yielding material and bears upon a hard stratum at its foot, its strength should be determined as a column or beam; omitting the resistance, if any, due to skin friction.

"(21) Unless the record of previous experience at the same site is available, the approximate bearing power may be obtained by loading test piles. The results of loading test piles should be used with caution, unless their condition is fairly comparable with that of the piles in the proposed foundation.

"(22) In case the piles in a foundation are expected to act as columns the results of loading test piles should not be depended upon unless they are sufficient in number to insure their action in a similar manner, and they are stayed against lateral motion.

"(23) Before testing the penetration of a pile in soft material where its bearing power depends principally, or wholly, upon skin friction, the pile should be allowed to rest for 24 hours after driving.

"(24) Where the resistance of piles depends mainly upon skin friction it is possible to diminish the combined strength, or bearing capacity, of a group of piles by driving additional piles within the same area."

Mr. W. J. Bergen (New York, Chicago & St. Louis) :—In clause 23 it says, "Before testing the penetration of a pile in soft material, where its bearing power depends principally or wholly upon skin friction, the pile should be allowed to rest for twenty-four hours after driving." Should this not read, "Before testing the bearing power," rather than the penetration?

The President:—If there is no further objection we will proceed.

The Secretary:—"(25) Where there is a hard stratum overlying softer material through which the piles are to pass to a firm bearing below, the upper stratum should be removed by dredging or otherwise, provided it would injure the piles to drive through the stratum. The material removed may be replaced if it is needed to provide lateral resistance.

"(26) In general, timber piles may be advantageously pointed to a 3-in. or 4-in. square at the end."

Prof. Jacoby:—The Committee desires to change the numerals in this case from "3-in. or 4-in." to "4-in. or 6-in." because a square of 3 in. is believed to be too small.

Mr. Courtenay:—I would like to see clause 26 eliminated. It is good practice to drive a timber pile without pointing the small end of it at all.

Prof. Jacoby:—Would it be considered more desirable to say, "in some cases," because others, who have extensive experience, find it is decidedly advantageous?

Mr. Courtenay:—If a pile can be driven without an iron shoe, I would not advocate pointing it at all. Personally, I am pretty suspicious of piles that are driven with an iron shoe. I think a large proportion of them are damaged.

The President:—We would like to have some other expressions of experiences in driving piles, with especial reference to the question of pointing.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis) :—I recall a case where we had to drive piles through the bottoms of flat boats or transports, that had been sunk during the war, and we could not get them through at all without shoes. The boats were absolutely sound, and with shoes we could get them through.

Mr. Snow:—I agree with the gentleman in his suggestion that No. 26 be omitted.

Mr. A. J. Himes (New York, Chicago & St. Louis) :—I have driven piles without shoes through loose rock which had been placed around piles, forming a previous foundation, and without difficulty. I have also driven piles without the use of shoes through material, in the beds of streams in Pennsylvania, that was full of large pieces of flat rock and boulders, and without any difficulty.

The President:—We are getting onto the question of shoes. We would like to hear something about pointing piles.

Mr. J. B. Jenkins (Baltimore & Ohio):—I have often found that while we could not get piles into the ground without pointing them, we could get them in in good shape by doing so. We also found pointing was very advantageous in other cases where it was difficult to keep them in line on account of obstructions. I have made it a practice to drive them without pointing when I could, but frequently it has been difficult to get them in at all unless they were pointed.

Mr. E. B. Temple (Pennsylvania Railroad):—It is my opinion that clauses 26 and 27 should stand practically as drawn by the Committee, except that the pointing should be increased to 4 to 6 in. In hard material piles should be pointed or they may split at the lower end and may not drive straight.

The President:—Mr. Courtenay, what is your idea about clause 26?

Mr. Courtenay:—I move to eliminate clause 26.

Mr. H. T. Porter (Bessemer & Lake Erie):—If you eliminate clause 26, I am afraid it will give the impression that this convention does not believe in pointing piles. Where you are driving piles into soil that is broken up, you can get them to go the way you want them to go better by pointing them, as they will not be deflected by small stones or hardened material. Where we drive piles in an old roadbed we point them, as a rule, and in a great many cases use steel points; where you have great depth of soil that does not change in its condition, like the bottoms of Illinois, you can drive piles probably to advantage with a square end, but I believe there are a great many conditions where the piles should be pointed, and if we change the expression, "in general," it is as far as we ought to go. I have done a great deal of work of this kind, and I have undertaken to teach my men to avoid sharpening the piles where they could use the square ends to advantage, simply for the purpose of saving the expense of sharpening, but we have found there are many cases in which it does not work; so I would suggest that it read, "in many cases, timber piles may be advantageously pointed to a 3-in. or 4-in. square at the end.

Mr. A. F. Robinson:—There are many places where there are boulders and cinders, and it is almost impossible to drive a pile unless it is pointed. In other cases where the soil is of a cinder character at the bottom, the piles have to be sharpened. If we cut out the clause about pointing piles, then we will have to modify the clause covering the shoe, which almost necessarily means the pile must be sharpened.

Mr. Courtenay:—There is nothing in the statement of recommended practice as to whether you should ordinarily sharpen piles or not. It is my belief it is not the best practice, but I fail to see if clause 26 should be withdrawn altogether, where there is anything in this series of articles which will tend to prevent a man from sharpening a pile if he seems to think it is best to do so. Opinions differ on this question. I tried sharpened piles where it is extremely difficult to drive them, and where it was of the utmost importance to have them driven quickly, and found that we could not drive them any faster when pointed than when they were not pointed. My experience also is that the pile will work away from its proper position more readily when it is pointed than when it is not. For that reason I am in favor of omitting clause 26, and if anyone wishes to point his piles, he can do that without departing from the recommendations given here. Simply let the Association refrain from making any recommendation as to whether they shall be sharpened or not.

Mr. R. G. Kenly (Minneapolis & St. Louis):—There are certain times when piles should be pointed, and I move as an amendment to Mr. Courtenay's motion that the two words, "in general," be omitted from that clause, and let the latter part of the rule stand as it is.

Mr. T. L. Condron (Consulting Engineer):—I offer an amendment to the amendment that the word "advantageously" be taken out.

Mr. Kenly:—There are times when the piles may be advantageously pointed.

Mr. Porter:—It seems to me if we say that piles may be advantageously pointed to a 4-in. or 6-in. square at the end, you indicate that that can be done under any and all circumstances, and I do not think any one is trying to advocate that. There must be some modifying expression in place of "in general" without saying "timber piles may be advantageously pointed"—that means under all circumstances.

Mr. Kenly:—I think that the words "may be" cover that point. "May be" leaves it optional, governed by the character of the soil you are driving in. "May be" does not say they *must be*. It does not specify the conditions under which they may or may not be pointed. If you cut out these two words, "in general," it is sufficient.

Mr. Snow:—Let Mr. Kenly change his amendment so we can put in, "in some cases," and allow the word "advantageously" to remain.

The President:—Is that satisfactory?

Mr. Porter:—I accept that.

Mr. Kenly:—That is satisfactory, but I do not see the necessity for it.

The President:—The Committee is willing to accept that change and the question is on the amendment to Mr. Courtenay's amendment, to eliminate clause 26, the amendment to the amendment being that the clause shall read, "timber piles may be advantageously pointed in some cases to a 4-in. or 6-in. square at the end."

(The amendment carried.)

The Secretary:—"(27) Piles need not be pointed when driven into comparatively soft material."

Mr. William McNab (Grand Trunk):—I assume that this Committee has presented its report, not to a kindergarten nursery, but to a practical body of engineers, and I ask them what is the reason for using the word "comparatively" in that clause? Their idea of "comparatively" may be different from that of others. If it has a meaning, it is all right. If it has no meaning, I move to strike it out.

Prof. Jacoby:—This is a large country and the soil conditions certainly vary considerably, so that the interpretation of a word like "comparatively" must have considerable latitude. A great deal has been said by men of large experience, contractors as well as engineers, in regard to the importance and influence of pointing on driving the piles straight. That condition does not hold when you get into material that is comparatively soft. Where to draw the line between the hard and the comparatively soft is very difficult, but that is where an engineer must certainly use his judgment. It is a question for the convention to determine whether the word "comparatively" should be eliminated.

Mr. McNab:—The word "comparatively" may be all right for the present moment, but when it appears in our Manual or comes before us in other print, we would not know what the Committee's actual idea of "comparatively" was. I contend that you can get the same import in this clause if you leave out the word "comparatively." Leave that to us as engineers.

The President:—The Committee is willing to accept your suggestion, Mr. McNab.

The Secretary:—"(28) Shoes should be provided for piles when the driving is very hard, especially in riprap or shale, and should be so constructed as to form an integral part of the pile."

"(29) The use of a cap is advantageous in distributing the impact of the hammer more uniformly over the head of the pile, as well as to hold it in position during driving."

Mr. McNab:—Is clause 29 necessary? Is it necessary to tell the Association that the use of a cap is advantageous? I do not think that that clause in the report is required.

Prof. Jacoby:—I think it may fairly be said, without any reflection upon the engineering profession, that the advantages of the use of a cap are not adequately appreciated throughout the entire country. This paragraph has been inserted because special attention has been called to it by contractors as well as engineers of very large experience and one instance may be cited in which a large number of the very finest longleaf yellow pine piles were to be driven in a certain location. Rings were employed and the results were not satisfactory, and then the cap was used. At first, in order to see whether the cap would be of any value, a thin plate was placed on the pile, and it was found that the piles could be driven to a sufficient depth without apparent injury, which could not be done without the plate. The cap was then sent for and used with entire satisfaction. Other similar illustrations might be given. I believe, after talking with many engineers and contractors on this subject, that the real value of the cap is not generally appreciated. Of course, one of the ideas the Committee has especially in mind, and which it has emphasized in its preceding reports, is the danger of over-driving. With larger experience in excavating piles which have been driven previously, in the reconstruction of lines this danger is found to be very much larger than used to be thought possible even two or three years ago.

Mr. McNab:—We are living in the twentieth century, and it does not seem necessary to recite what the use of a cap is. I think we might well leave out that special clause without injury whatever to the admirable report which the Committee has presented. It is all right for pupils in engineering colleges and other students, but hardly required for members of an association such as this.

The President:—Will you make a motion to eliminate?

Mr. McNab:—I submit a motion that this particular clause be left out, because I claim it will not do the slightest injury to any other part of the report. We will preserve the dignity and standing of the Association much better by leaving that particular clause out. I move that clause 29 be eliminated, as being superfluous.

Mr. F. S. Stevens:—It may be pertinent to remark that I have seen piles driven by the use of caps of thin boards of soft wood, where it was absolutely impossible to force them down by the use of rings—the piles would split in spite of the rings, but by the use of caps of soft wood the piles would drive without any apparent injury. As a general proposition, piles will drive better with a cap of soft wood across the top of the pile than with rings; I know it is done very successfully.

Mr. Porter:—I would be very sorry to see the clause omitted. We may be followed by younger men entering the engineering profession. They may have the finest possible technical education, but when one of these young men takes charge of some pile work, and desires a pile cap, it may be very difficult for him to explain just why he wanted it, whereas if this clause was added to his request, the matter would be simple. I think it would be unfortunate to leave out clause 29.

Mr. Steffens:—I am very glad indeed to hear Mr. Porter's remarks on that subject. The Committee's report is a summary of principles. The Committee has considered this matter for a number of years, and we should not hastily eliminate clauses in this report.

Mr. Himes:—Regardless of what we think ought to be or ought not to be incorporated in the report because of its elementary character, it is a fact that a great many piles are driven without caps. It is also a fact that many piles are driven with caps. I think it is a very pertinent thing for the Association to put its seal of approval on the use of caps.

Mr. George W. Kittredge (New York Central & Hudson River):—I would amend Mr. McNab's motion and retain the clause in this form: "The use of a cap is sometimes advantageous."

The President:—The motion is on Mr. Kittredge's amendment, which has been accepted by Mr. McNab, that clause 29 read as follows: "The use of a cap is sometimes advantageous," and strike out the remaining part of the clause.

Mr. E. B. Temple:—It seems to me that while it may be a good compromise, it is hardly necessary. I think we should leave the statement in regarding the use of the cap, and also refer to the ring, which is more generally used. These appear in all pile-driving specifications. I approve of the way the Committee has presented clause 29.

Mr. Kenly:—I would like to see the clause stand as it is. I do not see the necessity for putting the word "sometimes" in there. The use of the word "advantageous," in my estimation, does not mean it is always necessary. It means that you can use it as the exigencies of the case require. I am in favor of leaving it as it is.

Mr. C. H. Cartlidge (Chicago, Burlington & Quincy):—I believe the Committee has taken the trouble to look into this question of caps, along with the other things they have looked into, and I think it is hardly fair for those of us who have not considered the matter to take issue with them on the question that caps may be advantageously applied in general. If we find out in the future that caps will not work, we can make a change. At present I think we should leave the recommendations of the Committee as presented.

Mr. Porter:—If I understood Mr. McNab, the reason he wished to omit clause 29 was because everybody understood all about it, and now he accepts an amendment saying that the use of the cap is *sometimes* advantageous.

Mr. L. J. Hotchkiss:—In this question we are considering not only the driving of timber piles, with which we are all familiar, but the driving of concrete piles as well, with which many of us perhaps are not familiar. There is no way of driving a concrete pile without a cap unless you want to smash it to pieces. The concrete pile is still so new that I think we cannot be accused of running a kindergarten when we suggest that a cap be used in driving it.

(The amendment was lost.)

The Secretary:—"(30) The specification relating to the penetration of a pile should be adapted to the soil which the pile is to penetrate."

Mr. McDonald:—We have been quite patient under the constant hammering of my friend McNab on the question of good English. I think we also ought to be as scrupulous on the technical questions. I started to find fault with clause 20 and was told that clause 27 was a panacea for it. I do not find that that is the case. I therefore move that the word "need" in clause 27 be stricken out and the word "should" be substituted in its place. The reason is that in clause 20 we are told a pile driven in soft material must be treated as a column—nothing is said about how much bearing must be figured on for the end of the column.

The President:—The Committee accepts your suggestion changing the word "need" to "should."

The Secretary:—"(31) It is far more important that a proper length of a pile should be put in place without injury than that its penetration should be a specified distance under a given blow, or series of blows."

Mr. Himes:—These principles are apparently to stand alone independent of wooden bridges and trestles, and I want to say for the consideration of the Committee that sometimes in building concrete we use pile foundations and permit the concrete to rest directly on the piles. To cover such a case, I would suggest that we say, "Where masonry is to bear directly on the piles, such portions of the piles as may have been injured by contact with the hammer should be removed."

The President:—That matter will be considered by the Committee and reported on next year.

(The motion to adopt the principles of practice for pile-driving carried.)

Mr. G. D. Brooke (Baltimore & Ohio):—I would like to go back for a moment to the "Pile Record Form" on page 36. To bring this form into conformity with the forms of the Committee on Records and Accounts, it should be headed with the letters A. B. & C. R. R. Co., and the size of the sheet stated in a notation.

The President:—The Committee accepts that suggestion.

Prof. Jacoby:—The third conclusion relates merely to the acceptance of the balance of the report on Piles and Pile-Driving as information, and in connection with that I wish to have the privilege of presenting as discussion some material, which was received since the Bulletin was printed, because it contains the most complete statement on the phenomena of over-driving that has come into the hands of the Committee. It was obtained at the request of the Committee as the result of reading an article in Engineering News of February 23rd last. I desire to have this communication added as a part of the discussion of the report.

In Engineering News of February 23, there appeared an article by Mr. S. P. Brown, Chief Engineer of the Tide-Water Building Company, and Thomas B. Bryson, describing their experience with over-driven piles in the Brooklyn subway. In this work a large number of piles were driven to support temporary structures and later were excavated. Many of them were found to be over-driven, and Mr. Brown describes their condition and furnishes numerous illustrations showing the characteristic failures.

Information as to those things in the behavior of a pile in driving which indicate that it is being over-driven is very scarce. As Mr. Brown did not touch particularly upon this feature of the subject, your Committee requested him to furnish some additional data. He has kindly contributed the following discussion:

"It is very difficult to describe the indications of over-driving, because differences in the ground through which the pile is being driven produce very different effects in the behavior of the pile. In our case on the present subway construction we were driving through high, dry ground, which is a case that very seldom occurs in ordinary pile foundations. From a limited experience and study of piling work in various cases where piles have been uncovered, I have come to the conclusion that, in general, piles are apt to be over-driven and much of their value lost.

"I do not think there is any use in trying to establish a rule as to the weight and drop of the hammer in relation to the penetration of the pile, because such a formula would be worthless, unless the kind of pile was considered with regard both to its size and the quality of the material through which it is driven. There is, of course, a certain point at which the pile reaches its maximum value, this point being, in most cases, where any further driving would be detrimental to the pile itself. To know when to stop driving requires both judgment and experience. As usually the pile-driving is left to the judgment of an inspector who has had little or no actual knowledge or experience of the result of over-driven piles, the natural result follows: in his desire to be sure and get the pile down, he overdoes it.

"Where ground is fairly homogeneous, as soon as a pile begins to go hard and the hammer to bound, I consider it wise to stop driving. If driving is continued and the pile begins to go down irregularly, it is a pretty safe guess that the pile is either brooming up or collapsing like an accordion somewhere in its length. This indication, however, would mean nothing in the case of driving through stratified material where the pile would continue to break through one stratum into another of different density. In any case, if a pile suddenly changes direction, it leaves little doubt that it is broken. When the pile has not gone down very far, and one finds the hammer commencing to bound and the pile to shiver and spring near the ground, it is quite time to stop, unless, of course, the pile is disproportionately long for its diameter. As a usual thing when a pile is going down easily, and suddenly stops dead, and the hammer commences to bound, the driving might just as well be stopped, because the probabilities are that the pile has come up on a boulder or something of that sort.

"I have seen two piles driven side by side through the same ground and under the same conditions, as far as such a thing is practically possible, where one pile went down to its full length without being damaged and the other burst all to pieces, the cause being that one stick was sound and the other was what is called a red-heart. Both piles looked exactly alike except at the end, where a very little of the red-heart showed. In this case, the pile that failed appeared to go down rapidly and easily, but the head showed signs of distress at an early stage. The quality of a pile can usually be judged by the behavior of the head under moderate driving. As the driving progresses, the condition of the head also gives some indication of the condition of the pile below ground.

"The only way that I know to avoid over-driven piles is to make ample allowance in designing foundations to permit the piles to be under-driven rather than necessitate their being driven hard enough to injure them.

"As a usual thing, the man who is driving the piles, if he is experienced, knows when to stop, and, if he is honest, will not stop until it is time."

The President:—This will be incorporated in the Proceedings. It is moved that section 3 of the report on Piles and Pile-Driving be received as information. If the convention desires, we will take the matter up in detail. It is given in Appendix C. As this is quite a lengthy subject, and is treated simply as information, it is suggested that this be not discussed unless specially requested in order to save the time of the convention.

The next conclusion is No. 4. "Piling can be protected against Marine Wood Borers by filling sand between the ties and vitrified clay pipe placed around the piles from a point a foot or two below mud line to the same distance above high tide. The expense is such that it is not advisable to apply this treatment to piling which has not been protected against decay."

This recommendation of the Committee will be incorporated in the Manual, if approved.

Mr. Lloyd:—Instead of adopting that conclusion, I move that we accept it as information. It may or may not be true—I have no doubt it is largely true, but it may not be altogether true in many cases and I think it is just as valuable for the public at large and this Association if it is adopted for information. I make that motion.

(The motion carried.)

The President:—If there is no further discussion on the report, the Committee will be dismissed with the thanks of the Association for the splendid work which it has done.

WRITTEN DISCUSSION.

By Lincoln Bush, Consulting Engineer.

The writer considers it very important and the expenditure well warranted in first determining definitely by test borings or drilling what the actual depth and character of the foundation is before any detailed plans are prepared. Such determinations enable the designer to design the structure as it should be built to meet the conditions, assuming that the test borings or drillings have been properly made; and such an order of work saves much time in the designing room by eliminating numerous changes in plans where unexpected conditions arise when the foundations are being excavated, and which is frequently the case. In nearly all cases there is a hurry to start the foundation masonry and frequently plans cannot be or are not properly modified to suit the conditions and meet the requirements of economy. Furthermore, with a proper knowledge of the foundations the contractor is placed in possession of definite information, and with the plans properly designed once and for all, with possibly some minor modificatins, the result is a large economy to the company paying for the work, and which also eliminates questions of extra prices and frequently some arguments over changed conditions affecting unit prices.

The writer believes that, generally speaking, much damage is done by over-driving piles. He has had frequent examples of these conditions where old masonry in existing embankments was replaced by new masonry, the piles being driven in single lengths to a few feet below the bottom of the new foundations; the object in cases referred to being to support traffic over the new structure while construction was in progress. The writer has found many piles, driven under such conditions where the driving was hard, very seriously damaged and many of them were practically worthless for a support. In making excavation for the new structure the points of the piles were sometimes found from 6 to 8 ft. in a lateral direction from the tops of the piles, the piles being practically bent like a bow. The writer has also found other piles that were telescoped by being broomed from over-driving, and frequently found the upper end of the pile extending several feet below the broken top of the lower portion.

The water jet can be used to advantage and with economy in driving piles through hard material. The writer has in mind a 24-ft. arch built under his direction for carrying a new double-track embankment where the bank was about 90 ft. in height. Borings were made before the design of the structure was prepared and it was found that there was about 12 to 14 ft. of fine shale and sand from the surface down, and underlying this there existed a soft strata of wet, silty shale material of about 10 ft. in depth, and from this point down there existed for a depth of about 15 ft. a layer of fine, silty shale sand. The top layer above referred to was very hard material in which to drive piles, while in the middle strata of soft material the piles drove easily, and the lower strata was hard material in which to do driving. We expected with the great weight of embankment at this point that the soft strata would flow under the pressure. Eleven hundred piles were placed in the foundations of this structure and for all of them a water jet was used, a hole being first made with the jet from the ground surface to a point within about 10 ft. of where the bottom end of the pile would come. This hole was very quickly jetted down and the piles were readily driven and followed the course of the jetted hole and were brought to a good fetch-up in the driving with, we are sure, very little, if any, damage being done to the piles. It was necessary on account of the soft strata to put in piles under this structure carrying so heavy a load, and it would have been impracticable to have driven these piles without serious damage to them had the water jet not been used, and the cost of driving was very much less per pile.

By F. E. Schall, Bridge Engineer, Lehigh Valley Railroad.

The writer has read the report very carefully and desires to compliment the Committee upon the thoroughness with which the subject has been handled. The information contained in the report will be valuable to many engineers. The writer ventures to make the following suggestions with reference to the principles of pile-driving practice, the paragraphs being numbered the same as in the report:

(15) Mention might be made that the drop of the hammer should be reduced to suit the weight or strength of the pile.

(17) The reference about not using the water jet in certain locations should be emphatic, as a water jet used near existing structures may cause settlement or damage to such structures.

(23) To test the penetration of piles 24 hours after being driven entails considerable loss of time and expense, even if only one pile is tested of a certain group of piles driven to the same depth. In many cases it will be more economical to drive a few more piles than to wait for such tests.

(24) This statement may be made more definite if it is changed so as to read: Where the resistance of piles depends mainly upon skin friction, the driving of additional piles between a group of driven piles may diminish the combined strength or bearing capacity of all the piles.

(25) During the past season the writer had occasion to advise on a method of driving piles 55 ft. long through a hard embankment under track, while the leads of the pile driver were only about 40 ft. It was decided to fit a 12-in. wrought iron double strength pipe 25 ft. long with a steel point and cap, and drive the pipe 20 ft. into the embankment, then withdraw the pipe, drop the wooden pile into the form made by the pipe and drive the pile to the proper depth. This method might be advantageously applied in driving a hole through a hard stratum instead of removing it, as indicated in the report.

(29) In addition to the points mentioned relating to the use of a cap, the writer thinks the cap retards brooming on the head of the pile if the head is properly dressed to fit the cap.

In looking over Vol. 1, part 2, of the Handbuch der Ingenieurwissenschaften, to which reference is made, we find that in 1853 in the Ulverstone-Lancaster Railway, England, a water jet was used for setting cast-iron piles with disks across Marecombe Bay.

By B. A. Wood, Chief Engineer, Mobile & Ohio Railroad.

At the request of the Committee on Wooden Bridges and Trestles, it affords the writer much pleasure to submit a short written discussion of their report on the general subject of Piles and Pile Driving, published in Bulletin No. 129.

After a careful perusal of this report, anyone must be impressed with the carefulness with which it has been prepared, indicating a great amount of study and labor on the part of the Committee. The writer believes that it will meet with the approval of the Association, presenting, as it does, in concise form, the best obtainable information on the subject.

It is not believed that the Maintenance of Way Departments of railroads, as a rule, keep a pile record, whereas, in the construction of new lines, it is usually done, probably more with a view of making an estimate for the contractor than of forming a permanent record. It will undoubtedly be of great value to have such a record, although the main trouble will be in having it properly made out. It may mean the employment of an additional man, as the foreman generally has his hands full of other matters. It seems to be well worth the trouble and expense necessary to obtain it, for, with such a record at hand it would be possible to make out a bill of material and thereby save much valuable time in replacing the trestle, should it be destroyed, from any cause.

The Principles of Practice for Pile Driving, recommended for publication in the Manual, cover the most important points, to wit: Exploration of the soil, the water jet, over-driving, the bearing power of piles and the protection of piles. As to the first, too much stress cannot be placed upon the importance of a complete knowledge of the local conditions, for without such information one can neither design intelligently nor economically. In some locations the conditions vary greatly within a few feet. Especially do we find this along the banks of streams that are continually changing their courses.

The next items, relative to the water jet, bring to our minds the fact that this, as a means of sinking piles, has been greatly neglected. Every pile driver should be equipped with one, and its cost will be many times repaid if used only for lubrication. There are many locations where it should be used in sinking piles, saving time and money.

Paragraphs 13 to 17, inclusive, relate to the important subject of over-driving. These items emphasize the desirability of a steam hammer, and of a competent man in charge, whose experience and judgment will enable him to decide when a pile is being over-driven.

Items 18 to 24, inclusive, deal with the bearing power of piles. The first, dealing with the penetration of soft material, is of great importance. The writer knows of some structures whose supporting piles drive so easily and rapidly as to nullify any specifications requiring a minimum penetration per blow. Yet these structures have never settled, even under exceptionally heavy loading.

The necessity of protecting the pile from injury is dealt with in items 25 to 29, inclusive. Especially should the use of shoes be carefully considered. Although there are many who object to their use, or at least have very little faith in their efficiency, the writer's experience with them has been satisfactory. In one place, by using a cast-iron shoe, we were enabled to use piles for false work in the erection of an important bridge, securing sufficient penetration, in a rock bottom, to hold against a 20-ft. rise of the river and a swift current.

The last two paragraphs deal with the subject of penetration and seem to point out that as a means of determining the capacity of piles it is not of the importance we have heretofore attached to it. The last item covers the ground in a nutshell. The principal object to be obtained is to place a pile of proper length in its place without injury.

We are chiefly concerned, as Maintenance of Way Engineers, in the construction and maintenance of trestles and in the proper equipment for the work. On lines where the traffic is heavy, too much stress cannot be placed upon the efficiency of the plant, as frequently only a few hours of actual work can be put in each day, and every minute should be made to count. On page 48 of the Bulletin will be found an enumeration of the desirable features of a track pile driver. There is no question that one that combines all of these will be a most useful and economical machine.

Probably the most useful feature is that it should be provided with self-propelling mechanism. It seems to the writer that the saving to be effected thereby, practically doing away with the necessity of a locomotive and its crew, would justify quite a large expenditure in first cost. When we have provided sufficient power for this purpose the other important features of steam hammer, water jet, etc., naturally fall within the capacity of the machine.

In conclusion, it may be added that the writer has attempted a short discussion of this most excellent report in the hope that others, more familiar with the subject, will continue to elaborate upon it, to our mutual advantage and that of the roads we represent. The field is a good one and our stock of information small when compared with its importance. This Committee is accomplishing much good and should have all the assistance and encouragement we can give it.

REPORT OF COMMITTEE XVI.—ON ECONOMICS OF RAILWAY LOCATION.

(Bulletin 130.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The following is the outline of work for the year 1910, as requested by the Board of Direction:

1. Consider revision of Manual; if no changes are recommended, make statement accordingly.

2. Continue the consideration of all questions connected with railway location, grades, lines, and improvement of grades and lines affecting the economic operation with relation to traffic, tonnage, ratings, speed, density of traffic, and financial considerations, with the special aim in view of establishing uniform methods and unit values for investigating and analyzing the relative changes and costs of comparative routes or proposed grade reductions and line corrections.

3. Make concise recommendations for next year's work.

Realizing that authentic data with reference to operation of railways was necessary in order to proceed much further with the work as outlined, and knowing the nature of the "walls" with which the railway companies surround their statistics, the Chairman of your Committee sent the following letter to the Secretary, under date of April 6, 1910:

"Dear Sir:

"The Economics Committee has reached a point where we must secure some accurate operating statistics in order to proceed with our work. The data required is kept by all railways, in more or less complete condition, but it takes the time of employes to draw off the statements required, and in the majority of cases the data is considered confidential by the railway companies. This makes it difficult to secure the requisite data from the railways, but if the Directors and Officers of the Association, as well as such Committee members as can do so, will furnish from their own roads the data required, it will give the Committee substantial material to work upon. The Committee will hold all such information confidential, and in their reports will refer to the roads either by some designating number or letter. The clerical work of putting the required data in shape should be performed by the roads furnishing the information, as the Committee will be loaded with all the work that they can find time to accomplish, even though the information be furnished in its most complete form.

"In case the data required is kept for different portions of the road which might take a different classification under our standards of "A," "B," and "C" track, it will be essential that the information be given under its proper classification, as the ratios of expenses vary very materially under the different classifications. The following information is desired:

"(1) A statement of the percentage to nearest one hundredth per cent. that each of the Primary Accounts bears to the total Operating Expenses, based on the Interstate Commerce Commission's Classification of June, 1907.

(NOTE: It is desirable to have this cover a two-year period if possible)

"If further subdivisions of the Primary Accounts are kept, and if divided between passenger and freight traffic, the percentages for the various subdivisions should be given. It is particularly essential that the following accounts be subdivided, if possible, in order to make a proper analysis:

"Other Track Material;

"Railroad and Track;

"Bridges, Trestles and Culverts;

"Buildings, Fixtures and Grounds.

"If possible, it is particularly desirable that the following be divided between passenger and freight service:

"Station Employes;

"Road Enginemen;

"Fuel for Road Locomotives;

"Road Trainmen;

"Train Supplies and Expenses.

"(2) Operating expense per freight train mile.

"Operating expense per passenger train mile.

"If accounts are not separated so a reasonable division can be made, give the Operating Expense per train mile.

"(3) Trains per annum per mile of road: Freight; Passenger.

"(4) Approximate average running speed: Freight; Passenger.

"(5) Approximate tons train, including equipment: Freight; Passenger.

"(6) Number cars per train: Freight; Passenger.

"(7) Number pounds coal per train mile: Freight; Passenger.

"If fuel oil is used, the quantity per train mile for each class service should be given.

"The (2) to (7) data should be given for each class of track covered by reports received under clause (1).

"The Committee also needs further information with reference to relative wear of rail on curves, compared to wear on tangent under same traffic conditions. This is essential as one of the elements entering into the value of curvature.

"The information needed for this Committee's work is more difficult to procure than that required by most of the other Committees, and we must have the influence of our officials in order to get it. * * *"

The President of the Association answered as follows, under date of May 18, 1910:

"Chicago, May 18, 1910.

"Dear Sir:

"It has been my intention to take up the matter of securing information for the Committee on Economics of Railway Location, but up to the present I have not found time to do so. I will take this matter up in the immediate future.

"Yours very truly,

"(Signed) L. C. FRITCH, *President.*"

Under date of September 19, 1910, the President sent a letter to each member of the Board of Direction, requesting that they furnish the desired information.

Four replies have been received to the President's letter up to December 13, 1910. Other members of the Board may be compiling the information requested.

It is certain that nothing of real value can be done by this Committee if they are not furnished with sufficient information on which to base conclusions.

The work of this Committee is vitally connected with the economic operation of railways, and its work must cease if the railroads represented in this Association cannot furnish the required statistics.

Neither can the railways expect members of this Committee to devote hundreds of dollars' worth of time to the work if the roads take the position that they do not care to assume the expense of gathering the information.

Under date of May 16, 1910, the Chairman sent a communication to the members of the Committee and received six replies out of ten letters sent. This information is given to show that there are seven members of the present Committee who are willing to work, and that no censure can justly rest upon the heads of these willing members because of failure of the Committee to make a report.

The Chairman and some of the members are making such investigation as they may have time for, along the lines of the Committee's work, but these are individual studies which cannot extend beyond the narrow field of statistics immediately available.

The Chairman would recommend that the Committee be discharged from further study of the question, unless the Board considers the work of sufficient importance to furnish such information as may be required from time to time.

Respectfully submitted,

A. K. SHURTLEFF, *Chairman.*

Appendix A.

(Bulletin 127.)

BALANCED GRADES FOR USE OF ASSISTANT ENGINES.

By R. N. Begien, Assistant to Chief Engineer,
Baltimore & Ohio Railroad.

FORMULA FOR FREIGHT TRAIN RESISTANCE.

Bulletin No. 120 of the American Railway Engineering and Maintenance of Way Association shows, as adopted, the following as the formula for freight train resistance at slow speeds (7 to 35 miles per hour) on level tangent:

$$R = 2.2T + 121.6C$$

where R = total resistance of train,
T = weight of train in tons,
C = number of cars.

When resistance on grades is considered and "X" is the rate per cent. of the grade, we have

$$R = (20X + 2.2)T + 121.6C$$

Since the co-efficient of C is so near 122, it will be so taken, and the formula will then be

$$R = (20X + 2.2)T + 122C$$

RESISTANCE VARIES INVERSELY AS WEIGHT OF CAR.

This formula considers resistance to vary inversely as the weight of the car between the limits set by a 70-ton load and a 20-ton empty.

R for 1 70-ton car = 3.8 lbs. per ton.
R for 1 20-ton car = 8.3 lbs. per ton.

This is not exactly correct, but near enough for practice.

It is well known that some 70-ton cars will show a resistance as low as 2 lbs. per ton, and some 20-ton cars a resistance as high as 10 lbs. per ton.

The foregoing formula was the average result from a number of actual tests and is good enough to use as a basis for doing some figuring.

ABSOLUTE RATING IS CONSTANT.

The number of tons hauled may be figured as being in few or many cars, but the absolute rating for any given grade will be constant. Only the weight of the train will be lighter as the number of cars increases.

An example:

Let there be 38 cars of 70 tons each on a 0.3 per cent. grade,

$$\text{then } R = (6 + 2.2)T + 122C$$
$$T = 70C$$
$$R = 574C + 122C$$
$$R = 696C$$
$$C = 38 \text{ cars}$$
$$R = 26{,}448 \text{ lbs. of resistance.}$$

38 cars at 70 tons per car = 2,660 tons.

If we take an equal amount of resistance and use 20-ton cars on a 0.3 per cent. grade, we have

$$R = 26{,}448 \text{ lbs.} = (6 + 2.2)T + 122C$$
$$T = 20C$$
$$26{,}448 = 164C + 122C$$
$$= 286C$$
$$C = 92.4 \text{ cars}$$
$$T = 1{,}848 \text{ tons.}$$

ADJUSTMENT DUE TO WEIGHT OF CAR.

The resistance of 2,660 tons in 70-ton cars and 1,836 tons in 20-ton cars being the same (26,448 lbs.), it is evident that an adjustment has been made for the weight per car.

If we add 15 tons per car to the 70-ton per car train and 15 tons per car to the 20-ton per car train, we will find the total tonnage of each train is about the same.

$$38 \text{ cars} \times 85 \text{ tons} = 3{,}230$$
$$92 \text{ cars} \times 35 \text{ tons} = 3{,}220$$

This 15 tons is known as the adjustment. It is a function of the grade (in that it will vary with the grade) and of the co-efficient of C. It is obtained by dividing the co-efficient of C by the sum of the pounds per ton resistance due to grade and the co-efficient of T.

Following are the adjustments for the different grades from level to 2 per cent.:

TABLE OF ADJUSTMENTS.

Adjustment in tons per car.

Grade.	*Tons.*	*Grade.*	*Tons.*
0.0	55.0	1.1	5.0
0.1	29.0	1.2	5.0
0.2	20.0	1.3	4.0
0.3	15.0	1.4	4.0
0.4	12.0	1.5	4.0
0.5	10.0	1.6	4.0
0.6	9.0	1.7	3.0
0.7	8.0	1.8	3.0
0.8	7.0	1.9	3.0
0.9	6.0	2.0	3.0
1.0	6.0	...	...

It will be noted that the adjustment decreases with the rate of grade. At 0.7 per cent., it is 8 tons per car (these adjustments are given nearest even ton per car).

RESISTANCE OF 1,330-TON TRAIN OF 70-TON LOADS—.75 PER CENT. GRADE.

The resistance of a train of 70-ton cars weighing 1,330 tons on a 0.75 per cent. grade is

$$R = (15 + 2.2)T + 122C$$
$$R = 17.2T + 122C$$
$$C = 19$$
$$R = 17.2 \times 1{,}330 + (122 \times 19)$$
$$R = 25{,}194$$

Bearing in mind that the draw bar pull of the locomotive behind the tender must equal the train resistance, and examining the case again, we see that

R on a 0.3 per cent. grade with 2,660 tons = 26,448 lbs.
R on a 0.75 per cent. grade with 1,330 tons = 25,194 lbs.

By adding on the grade resistance in each case for a locomotive and tender weighing 166 tons, we have

$$26{,}448 \text{ lbs.} + (0.3 \times 20 \times 166) = 27{,}444 \text{ lbs.}$$
$$25{,}194 \text{ lbs.} + (0.75 \times 20 \times 166) = 27{,}614 \text{ lbs.}$$

Note that the totals are about equal in both cases.

BALANCED GRADE FOR 0.3 PER CENT.

The foregoing means that what one engine can haul up a 0.3 per cent. grade needs two engines of the same class on a 0.75 per cent. grade, and that each engine must develop between 27,444 and 27,614 lbs. of cylinder tractive effort; in other words, the helper engine grade for a 0.3 per cent. grade is a 0.75 per cent. grade—the same class of power being considered.

If the adjustment was the same for all grades and the resistance of loads and empties the same, it would be found that the rate of the helper grade was considerably higher.

For example:

Let R = 6 lbs. per ton in all cases, and the rate of helper engine grade is found to be about 0.9 per cent.

WELLINGTON'S FIGURE.

In his book, A. M. Wellington gives it as 0.94 per cent. He advises the use of a grade 10 per cent. less than the figured grade, which would make about 0.85 per cent. This latter rate has been used indiscriminately in the past, and many roads are today paying for it. In other words, *the helper grades are in many cases the ruling grades.*

Following is a general formula for computing rate of helper grade for any case, whether helping power is equal to road power or not:

Formula for Computation of Rate Per Cent. of Helper Grade.

Let R = drawbar pull of road engine behind tender at given speed on level tangent,
R[1] = drawbar pull of helper engine behind tender at given speed on level tangent,
W = weight of road engine and tender, in tons,
W[1] = weight of helper engine and tender in tons,
T = tons of weight of train,
C = number of cars in train,
G = single engine grade per cent.,
X = rate per cent. of helper grade.

Then a single engine will haul on X grade:

$$R - (20 \times W) = (20X + 2.2)T + 122C$$

Both engines will haul on X grade:

$$[R - (20 \times W)] + [R^1 - (20 \times W^1)] = (20X + 2.2)\ T + 122C$$
$$R - 20XW + R^1 - 20XW^1 = 20XT + 2.2T + 122C$$
$$R + R^1 - 2.2T - 122C = 20XT + 20XW + 20XW^1$$
$$= X(20T + 20W + 20W^1$$
$$X = \frac{R + R^1 - 2.2T - 122C}{20(T + W + W^1)}$$

The following table of balanced grades assumes that the helper can do about 10 per cent. more work than the road engine.

This should be a fact, as the helper engine's work is not sustained for long periods of time. These figures should be safe for grades not more than 10 miles in length.

BALANCED GRADES FOR HELPER ENGINE SERVICE.

NOTE.—Values given are based on coal consumption of 4,000 lbs. per hour for road engine and 5,350 lbs. per hour for helper (E-24 engines—13,000 B.t.u. coal).

Road Engine Grades.	*Helper Engine Grades*		
	1 Helper.	*2 Helpers.*	*3 Helpers*
Level	0.204	0.400	0.587
0.05	0.302	0.536	0.766
0.10	0.401	0.673	0.946
0.15	0.497	0.813	1.114
0.20	0.594	0.954	1.283
0.25	0.688	1.083	1.441
0.30	0.782	1.212	1.599
0.35	0.874	1,336	1,749
0.40	0.966	1.461	1.899
0.45	1.055	1.580	2.039
0.50	1.145	1.699	2.179

Road Engine Grades.	*Helper Engine Grades*		
	1 Helper.	*2 Helpers.*	*3 Helpers.*
0.55	1.233	1.813	2.311
0.60	1.321	1.928	2.444
0.65	1.407	2.037	2.569
0.70	1.494	2.147	2.695
0.75	1.578	2.253	2.814
0.80	1.662	2.359	2.933
0.85	1.744	2.460	3.045
0.90	1.826	2.561	3.158
0.95	1.907	2.659	3.271
1.00	1.988	2.757	3.384

Compared to the foregoing, Wellington published the following table in his book on the "Economic Theory of the Location of Railways":

BALANCE OF GRADES FOR THE USE OF ASSISTANT ENGINES.

(Correct within an unimportant percentage for all classes of engines and conditions of service, the through and pusher engines having the same weight and tractive power.)

Through Grade Worked by One Engine.	*Grade Up Which the Same Train Can Be Hauled by the Aid of*		
	One Pusher.	*Two Pushers.*	*Three Pushers.*
Level	0.38	0.74	1.08
0.05	0.47	0.87	1.25
0.10	0.57	1.00	1.41
0.15	0.66	1.13	1.57
0.20	0.75	1.26	1.74
0.25	0.84	1.39	1.89
0.30	0.94	1.52	2.05
0.35	1.03	1.64	2.20
0.40	1.12	1.76	2.35
0.45	1.21	1.88	2.49
0.50	1.30	2.01	2.64
0.60	1.47	2.24	2.92
0.70	1.65	2.47	3.20
0.80	1.82	2.69	3.45
0.90	1.99	2.91	3.70
1.00	2.16	3.13	3.95
1.10	2.32	3.33	4.20
1.20	2.48	3.55	4.42
1.30	2.64	3.73	4.65
1.40	2.81	3.93	4.87
1.50	2.96	4.13	5.07
1.60	3.13	4.32	5.27
1.80	3.43	4.68	5.68
2.00	3.72	5.03	6.04

Through Grade Worked by One Engine.	*Grade Up Which the Same Train Can Be Hauled by the Aid of—*		
	One Pusher.	*Two Pushers.*	*Three Pushers.*
2.20	4.01	5.35	6.40
2.40	4.30	5.67	6.73
2.60	4.57	6.00	7.05
2.80	4.86	6.30	7.34
3.00	5.10	6.58	7.63

The foregoing is submitted in the light of information secured since Wellington wrote his admirable book.

DISCUSSION.

(In the absence of Mr. A. K. Shurtleff, Chairman of the Committee on Economics of Railway Location, the report was presented by the Vice-Chairman, Mr. R. N. Begien, Assistant to the General Manager, Baltimore & Ohio Railroad.)

Mr. R. N. Begien (Baltimore & Ohio):—I am sorry Mr. Shurtleff is not here to make a statement to the convention with regard to the failure of the various railways to furnish data for the Committee to work on. Up to the present time I believe answers have been received from about seven railroads, those being the railways represented by the members of the Board of Direction, giving operating data with which the Committee can compute values for various operating statistics, distance, curvature, and rise and fall. There has been no meeting of the Committee this year. There did not appear to be any necessity for a meeting, as there was but little data to work with. The Sub-Committee which had in charge the subject of tonnage rating with respect to economical operation has conducted certain tests on the Baltimore & Ohio Railroad this year to determine train resistance. In order to make those tests final and as conclusive as possible, engineering corps were organized to run the profiles of the various divisions which were to be examined. Tests of passenger trains were first made. There were 14 runs, aggregating 4,000 miles. Then there were 12 runs made of fast freights, with an idea of examining particularly speeds between 20 and 50 miles an hour of freight trains, and after that, about 6,000 miles of slow freight runs were made.

We were able to examine the resistance on two divisions only, owing to the time between the finishing of the runs and the time of this convention. On these runs we took observations for coal consumption, water, steam, train line, positions of the reverse bar and the throttle, and in examining the water consumption, both the calibration of the tank was made, and the number of minutes that the injector was in service. We have all of the material for making a very complete report, but it is going to take considerable time to do it. I might state, as a matter of interest, that a year ago the Committee reported that on slow freight work but little change of resistance was noted between 5 and 35 miles per hour. After examining the work on our Newark division, between those same speeds, I believe that we are justified in still making that contention. There have been some experiments made during the year which would not seem to bear out that contention, but I believe that on mixed trains, containing cars of various weights, that it can be safely said that for all practical purposes there is but little change in resistance between 5 and 35 miles per hour. Another point of interest that was noted was in connection with temperatures. One train which was taken out of our yard at Newark, Ohio, had been standing there all night, and it took two engines to get it out of the yard, although the grade was only a ruling grade—in fact, slightly below the ruling grade—and for nearly two hours after the train had proceeded it was noticed that the resistance was up. The train resistance on leaving the yard was about 20 pounds to the ton, and stayed up to that point for only half an hour, and it was not until the train went over the summit, nearly two hours later, that the normal resistance began to be noted, which would average very closely to what was established in the formula adopted by this convention last year. In fact, I might say that up to date the net results of the experiments have been that the formula published in the Proceedings last year appears to be a fairly good formula for practical use.

The President:—This is one of the most important Committees of this Association, and the Board of Direction has given careful thought and attention to the Committee, and it can be said that there is one recommendation which the Chairman of the Committee made which the Board of Direction and the Association is not ready to adopt, and that is the recommendation that this Committee be discharged from further study of the question. It is the intention, for the members of the Board of Direction at least, to make every possible effort to furnish information to this Committee. We all realize how difficult it is to furnish information, especially of a nature requiring additional clerical work, and that has been one of the reasons why this Committee has not been able to get information which it asks for, but the Committee has done splendid work, but much is yet to be done, so that this Committee will certainly be continued. Mr. Shurtleff has given a lot of his valuable time, energy and skill to this work, and we are not ready to accept his resignation. I think the Association should give this Committee all the assistance and support possible in the way of information, because without information this Committee cannot carry on its work.

Mr. J. M. Meade (Santa Fe):—I understood the Chairman of the Committee to say that they had the data, but they had not had time to formulate it. Now, it seems to me that we ought to give them help, if they have the data, and get it in shape to present for final report.

The President:—A certain amount of data was furnished, and much of it was furnished so late that it could not be incorporated in this year's report. But as the member of the Committee who presented the report stated, only seven railways have submitted replies to the Committee's request for information.

Mr. George W. Kittredge (New York Central & Hudson River):—I want to say, possibly in justification of those who have not given the Committee all they desire, that there is really very little information available in actual figures and tests. We all know and appreciate what advantages have arrived from economic location of roads and changing grades, but very few of us have any figures that we can put into print, showing the actual economies that have been accomplished by changing grades. In justification for the road with which I am connected, and as a reason why we have not furnished the information desired by the Committee, that we simply have not got it in a shape that would do any good. We know that economies have resulted from reducing grades and eliminating curvature, but so many things have entered into the final results, besides the changing of grades and eliminating curvature, that we have no figures to show results from those particular things. I appreciate very fully the position of the Committee, in its inability to get information, and yet I do not think it is putting the roads that have not furnished the information quite in the proper light to say they have not furnished it, leaving the impression that they have been negligent. In our case, we have not been negligent; we have been unable to give it in the way it is wanted.

Mr. A. W. Thompson (Baltimore & Ohio) :—The results of the dynamometer tests which Mr. Begien has mentioned will be platted up, and the full result and report will be gotten up by the Baltimore & Ohio and given the Committee. The importance of the work of this Committee I do not believe is appreciated, and I rather think that some of the railroads, with due respect to the remarks of Mr. Kittredge, have not felt the importance of the Committee's work, and they probably thought that they did not have any data on this subject. Every little bit helps, and I believe that if each railroad in answering the Committee's letter—or, to go back, would recognize the letters that have come in and not lay them aside, that the Committee would go farther than they have gone in making an intelligent report. To show the value of one point that Mr. Begien makes, of the resistance of trains out of yards, we are spending on two new yards that we are completing, an additional amount of about $60,000 to reduce the grade out of the yards and give the trains an opportunity to get out promptly. It was demonstrated how slowly trains move out of departure yards. From a transportation standpoint, it is necessary to have the trains move promptly. Data of this kind is what the railroads need, and we should give all the help we possibly can to this Committee.

The President:—If there are no further remarks, the Committee will be relieved with the thanks of the Association.

REPORT OF COMMITTEE II.—ON BALLAST.

(Bulletin 129.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Ballast begs to submit the following report:

Two meetings were held during the year at the rooms of the Association in Chicago, one on May 26, at which the following members were present: C. A. Paquette, Vice-Chairman; W. J. Bergen, C. S. Millard, C. T. Brimson, J. M. Meade; and another on October 6, at which the following members were present: John V. Hanna, Chairman; F. J. Stimson, S. N. Williams, W. J. Bergen, C. C. Hill.

On April 27, by letter, Sub-Committees were appointed as follows:

Sub-Committee A, Revision of Manual:
F. J. Stimson, Chairman;
W. J. Bergen,
C. B. Brown, Jr.

Sub-Committee B, Completing Physical Tests of Stone for Ballast:
F. J. Bachelder, Chairman;
C. S. Millard,
C. T. Brimson.

Sub-Committee C, Proper Thickness of Ballast:
H. E. Hale, Chairman;
J. M. Egan,
S. N. Williams.

Sub-Committee D, Review Report on Gravel Ballast:
J. M. Meade, Chairman;
J. S. Lemond,
C. C. Hill,
G. D. Hicks.

At the meeting on May 26 a suggestion was made to the members present that an effort be made to confer with the Masonry Committee with a view to agreeing upon a definition of sand which would serve for both Committees. This is covered by the report of Sub-Committee A, as follows:

REPORT OF SUB-COMMITTEE A—REVISION OF MANUAL.

Certain changes were made in the wording in the Manual in order to get the changes incorporated in the new edition.

The term "Broken or crushed rock" was changed to "Stone Ballast," inasmuch as stone seems to be the most common expression used by railroad men in speaking of ballast of this nature.

Paragraph 2 was changed so as to combine "A" and "B" to read as follows:

"It shall be broken into pieces of such size that they will, in any position, pass through a 2½-inch ring and will not pass through a ¾-inch ring.

"It shall be free from dirt, dust or rubbish."

The heading, "Gravel, Cinders and Burned Clay Ballast," has been made to read "Gravel, Cinder and Burned Clay Ballast."

The first paragraph has been made to read "Gravel Ballast," instead of "Gravel." The last part of this paragraph has been eliminated, and in place thereof the specifications have been introduced.

The second paragraph covering Cinder Ballast has been headed "Cinder Ballast" instead of "Cinders."

Proof for the new edition of the Manual was corrected generally, so that, in the opinion of the Committee, it makes better wording.

DEFINITION OF SAND.

The proposition to change the definition of "Sand" so as to make it coincide with that given by the Masonry Committee or to formulate a compromise definition does not appear to be tenable. The use to which the material is to be put governs the nature of the definition entirely. It must be conceded by all that the term "Sand" as used by the Masonry Committee, as well as by the Committee on Ballast, is entirely empirical. There are no mechanical or chemical tests that will determine scientifically where the dividing line between gravel and sand and between sand and dust lie. These divisions will vary as the use to which the material is to be put varies.

The only definition which can be used that is common to each Committee would be that formerly used by the Ballast Committee, but discarded at the 1909 convention, viz.: "Any hard, granular, comminuted rock material, finer than gravel and coarser than dust." As a general, all-comprehensive definition, this cannot be excelled, but as a definition of what is meant by either the Ballast or Masonry Committees when using the term "Sand" in specifications, nothing could be more misleading or indefinite.

As the use of the term by each Committee is entirely empirical and the definitions used refer to that arbitrary use of the term, it appears that it is not desirable to make any change in this Committee's definition. As a matter of fact, the Masonry Committee, so far as we can find in the Manual, do not define "Sand," but do give specifications for different qualities of sand which is to be used for different purposes.

Your Sub-Committee recommends, therefore, that the definition of sand remain as adopted in 1909, viz.: "Any hard, granular, comminuted rock which will pass through a No. 10 screen and be retained upon a No. 50 screen."

REPORT OF SUB-COMMITTEE C—PROPER THICKNESS OF BALLAST.

Some of the reasons for the use of ballast in track construction are as follows:

(a) To provide drainage which will lead any water that may accumulate away from the ties; or to provide a protection for the subgrade from water, as in the case of cementing gravel.

(b) To distribute the load from the ties more uniformly over the subgrade than would be done if the ties rested directly upon the subgrade.

(c) To provide a material which can readily be "worked" or tamped in all kinds of weather and which will not materially lose its carrying power or change its position as a result of the action of the elements.

The proper depth of ballast under the ties will depend, among others, upon the following:

(a) The character of the subgrade:
- (1) Rock.
- (2) Firm material, as firm gravel.
- (3) Soft material, as gumbo.

(b) The kind of ballast:
(This affects the depth of ballast but slightly compared with other conditions.)

(c) The number and size of ties per rail length:
(This determines the bearing surface on the bottom of the tie in a given length of track.)

(d) The stiffness of the rail:
- (1) 135-lb. used on C. R. R. of N. J.
- (2) 40-lb. used on branches.

(e) The weight and magnitude of the wheel load and the number of applications in a given period:
- (1) 100 cars per day.
- (2) 2,000 to 3,000 cars per day.

(f) The cost of materials used in construction of the track.

CHARACTER OF SUBGRADE.

If the subgrade is of rock it will not be deformed by wet weather and it will carry all the load that can be put upon it by a timber tie; therefore, the depth of ballast required in this case is only sufficient to provide an equal bearing under the tie and sufficient material for tamping purposes.

If the subgrade is soft, then it is necessary to provide a depth of ballast which will produce as nearly as possible a uniform pressure on the subgrade.

In a lecture delivered by Railroad Director Schubert before the "Verein für Eisenbahnkunde," at Berlin, Germany, on March 14, 1899 (see Proceedings, American Railway Engineering and Maintenance of Way Association, Vol. 7, p. 105), it was stated from experiments made during

1887 to 1890 that "a given railroad track whose roadbed consists of clay, a swelling of same between the ties will not occur even under the most favorable conditions when the height of the bed (depth of ballast under tie) is increased eight inches over the clear distance between the ties." The tests and results of same are very clearly given in the above- mentioned lecture.

There is a report on "Strength of Track for High Train Speeds," made to the International Railway Congress by the Reporter for America, Mr. M. L. Byers, Chief Engineer Maintenance of Way, Missouri Pacific Railway, which may be found in Engineering News of February 3, 1910. This article is of considerable interest in the discussion of the proper depth of ballast.

Between solid rock and soft material, such as gumbo, there exists material used for subgrade of various capacity for supporting the load of the track. The softer the material used in the subgrade, the deeper should be the ballast (within certain limits), to provide as uniform pressure on the subgrade as possible.

KIND OF BALLAST.

The required depth of ballast under the tie is not materially affected by the kind of ballast, although it is generally the practice to provide a less depth of stone ballast than gravel ballast. (This is probably largely affected by the high cost of stone.)

NUMBER AND SIZE OF TIES PER RAIL LENGTH.

The number of ties per rail length, where the roadbed is soft, materially affects the depth of ballast, for the fewer the ties the greater the weight on each tie, and a greater depth of ballast will be required to distribute the load more uniformly over the subgrade.

STIFFNESS OF THE RAIL.

The stiffness of the rail materially affects the depth of ballast, for with the stiffer rail the wheel load is distributed over a greater number of ties and therefore the load on each tie is reduced. The unit weight being less, it is not necessary to distribute same as uniformly on the subgrade.

WEIGHT AND NUMBER OF WHEEL LOADS.

The greater the weight and number of wheel loads the greater the necessity for increased depth of ballast, so as to distribute the weight on the subgrade as uniformly as possible.

COST OF MATERIAL USED TO CONSTRUCT THE TRACK.

From an economic standpoint the proper depth of ballast frequently depends on the cost of the various materials of which the track is constructed; for example, where ballast is very expensive it may be advisable to increase the weight of rail and cut down the depth of ballast.

DIMENSIONS OF BALLAST SECTION.

As information, an appendix "A" is given, being a statement giving the dimensions of the ballast sections on various railroads.

CONCLUSION.

On account of the complicated conditions which govern the proper depth of ballast, your Sub-Committee feels unwilling to recommend any definite rule for the proper depth of ballast, but offer the above information as a guide to determine the proper depth of ballast where the local conditions are known.

Sub-Committee B has not submitted a report.

Sub-Committee D did considerable work upon the subject assigned to it and submitted a report to the General Committee. It was the opinion of the members present at the meeting of October 6 that it was advisable to consider the subject of gravel ballast further before adopting the Sub-Committee report. The latter was accordingly referred back to the Sub-Committee for further investigation.

Your Committee asks that the recommendations contained in the report of Sub-Committee A, Revision of Manual, be adopted.

The Committee requests that the other matters assigned to the Ballast Committee be referred back for further consideration. Some, if not all, of the members feel that there is much valuable information to be gained by further investigation of the subject of proper thickness of ballast; that independent investigations, with possibly some instrument designed for the purpose of measuring actual pressure transmitted by ballast, can be made with profit.

Respectfully submitted,

John V. Hanna, Chief Engineer, Kansas City Terminal Railway, Kansas City, Mo., *Chairman.*

C. A. Paquette, Assistant Chief Engineer, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, Ohio, *Vice-Chairman.*

F. J. Bachelder, Division Engineer, Baltimore & Ohio Railroad, Cleveland, Ohio.

W. J. Bergen, Assistant to Chief Engineer, New York, Chicago & St. Louis Railway, Cleveland, Ohio.

C. T. Brimson, Engineer Maintenance of Way, Quincy, Omaha & Kansas City Railway, Kansas City, Mo.

C. B. Brown, Jr., Division Engineer, Canadian Pacific Railway, Montreal, Canada.

J. M. Egan, Roadmaster, Illinois Central Railroad, Fulton, Ky.

H. E. Hale, Principal Assistant Engineer, Missouri Pacific Railway, St. Louis, Mo.

G. D. Hicks, Superintendent, Nashville, Chattanooga & St. Louis Railway, Tullahoma, Tenn.

C. C. Hill, Division Engineer, Michigan Central Railroad, Niles, Mich.

J. S. Lemond, Engineer Maintenance of Way, Southern Railway, Charlotte, N. C.

J. M. Meade, Engineer Eastern Lines, Atchison, Topeka & Santa Fe Railway, Topeka, Kan.

C. S. Millard, Engineer Track and Roadway, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, Ohio.

F. J. Stimson, Engineer Maintenance of Way, Grand Rapids & Indiana Railroad, Grand Rapids, Mich.

S. N. Williams, Professor of Civil Engineering, Cornell College, Mt. Vernon, Iowa.

Committee.

Appendix A.

STATEMENT SHOWING DEPTH OF BALLAST USED BY VARIOUS RAILROADS.

Name of Railroad.	Class of Track.	DEPTH OF BALLAST UNDER TIE.							
		Center of Tie—Kind of Ballast.				End of Tie—Kind of Ballast.			
		Rock.	Gravel.	Cinders.	Sand.	Rock.	Gravel.	Cinder.	Sand.
Baltimore & Ohio........	A	a12 in.	b12 in.	12 in.	....	a12 in.	b12 in.	12 in.	....
	B	9 in.	9 in.	9 in.	....	9 in.	9 in.	9 in.	....
	C	6 in.	6 in.	6 in.	....	6 in.	6 in.	6 in.	....
Boston & Maine.........	A	....	12 in.	....	....	....	12 in.	....	....
	Bd	....	12 in.	....	....	....	15 in.	....	....
Canadian Pacific.........	A	7 in.	7 in.	7 in.	....	9 in.	9 in.	9 in.	....
	B	....	7 in.	7 in.	....	....	9¼ in.	9¼ in.	....
Chicago & Alton.........		e12 in.	12 in.	f12 in.	....	e13½ in.	13½ in.	f12 in.	....
Chicago, Burlington & Quincy		8 to 12 in.	8 to 12 in.	8g to o12 in.	....	8 to 12 in.	8 to 12 in.	g8 to 12 in.	....
Chicago Great Western..	A	12 in.	12 in.	12 in.	....	13 in.	13 in.	13 in.	....
	B	9 in.	9 in.	9 in.	....	10 in.	10 in.	10 in.	....
	C	6 in.	6 in.	6 in.	....	7 in.	7 in.	7 in.	....
Chicago, Milwaukee & St. Paul...............	A	....	h12 in.	12 in.	....	....	h12 in.	12 in.	....
	B	....	h10 in.	10 in.	....	....	h10 in.	10 in.	....
	C	....	h8 in.	8 in.	....	....	h8 in.	8 in.	....
Denver & Rio Grande....	A	....	12 in.	....	....	....	12 in.	....	....
	B	....	10 in.	....	....	....	10 in.	....	....
	C	....	8 in.	....	....	....	8 in.	....	....
	D	....	6 in.	....	....	....	6 in.	....	....
New York, New Haven & Hartford............		9 in.	7 in.	7 in.	7 in.	k8 & 10 in.	9½ in.	9½ in.	9½ in.
Pennsylvania		6 in.	6 in.	6 in.	....	7 in.	7 in.	7 in.	....
Rock Island Lines........	A	m6 to 10 in.	6 to 10 in.	6 to 10 in.	n6 to 10 in.	m6 to 10 in.	6 to 10 in.	6 to 10 in.	n6 to 10 in.
	B	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.
	C	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.
St. Louis Southwestern..	*	12 in.	12 in.	12 in.	12 in.	13 in.	13 in.	13 in.	13 in.
St. Louis & San Francisco	A	o6 to 10 in.	6 to 10 in.	6 to 10 in.	p6 to 10 in.	o6 to 10 in.	6 to 10 in.	6 to 10 in.	p6 to 10 in.
	B	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.
	C	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.	6 to 10 in.
Texas & Pacific..........	*	8 in.	8 in.	8 in.	....	9 in.	9 in.	8 in.	....
Wabash	A	r8 in.	....	....	....	r12 in.	....	....	....
	B	r12 in.	....	....	....	r8 in.	....	....	....

STATEMENT SHOWING DEPTH OF BALLAST USED BY VARIOUS RAILROADS.—Continued.

Name of Railroad.	Height and Slope of Shoulder.	Width of Roadbed.			
	Dist. from Top of Tie to Top of Shoulder.	Slope.	Cuts.	Fills.	Tile Drains.
Baltimore & Ohio........	1½ in. 1½ in. 1½ in.	c1½ to 1 1½ to 1 1½ to 1	18 ft. 16 ft. 14 ft.	20 ft. 18 ft. 16 ft.	....
Boston & Maine.........	1 in. Bottom of tie	1½ to 1 Curved	19 ft. 5 in. 18 ft.	19 ft. 5 in. 18 ft.	....
Canadian Pacific.........	Top tie rock Others 1 in.	Curved Curved	16 ft. 14 ft.	16 ft. 14 ft.	....
Chicago & Alton.........	Top tie rock, bot. gr'v'l	1¼ to 1 curved	18 ft.	18 ft.	....
Chicago, Burlington & Quincy	1½ in.	Rock 1½ to 1 Others 2 to 1	18 ft.	18 ft.	6 & 8 in. pipe under ditch
Chicago Great Western..	Top of tie, bot. for cementing gravel	1¾ to 1 1¾ to 1 1¾ to 1	20 ft. 18 ft. 16 ft.	20 ft. 18 ft. 16 ft.	....
Chicago, Milwaukee & St. Paul...............	1½ in. 1½ in. 1½ in.	2 to 1 2 to 1 2 to 1	....	....	....
Denver & Rio Grande....	About 1 in. About 1 in. About 1 in. About 1 in.	Curved Curved Curved Curved	18 ft. 18 ft. 18 ft. 18 ft.	20 ft. 20 ft. 20 ft. 20 ft.	....
New York, New Haven & Hartford............	Top tie rock Others 3 in.	1-1 rock 2-1-others	16 ft.	16 ft.	....
Pennsylvania	Top rock and cinder 1 in. above bot. gravel	1½ to 1	14 ft. 8½ in.	21 ft. 8½ in.	6 in. C. I. pipe cross drain
Rock Island Lines.......	1½ in. 1½ in. 1½ in.	2 to 1 2 to 1 2 to 1	20 ft. 18 ft. 16 ft.	20 ft. 18 ft. 16 ft.	C r o s s drain where needed
St. Louis Southwestern..	Top tie rock, bot. sand	1½ to 1	17 ft.	18 ft.	....
St. Louis & San Francisco	1½ in. 1½ in. 1½ in.	2 to 1 2 to 1 2 to 1	20 ft. 18 ft. 16 ft.	20 ft. 18 ft. 16 ft.	....
Texas & Pacific..........	1 in. from bottom, top tie rock	1½ to 1 1 to 1 rock	18 ft.	15 ft.	....
Wabash	Top of tie Top of tie	Curved Curved	18 ft. 16 ft.	18 ft. 16 ft.	....

Remarks.

a Includes hard slag.
b Incl. granulated slag.
c Slope is being changed from c'rv'd to 1½ to 1.
d Roadbed has transverse slope ¾ in. to 1 ft. In wet ledge cuts, depth of ballast is sometimes increased to 2 ft.
e Includes furnace slag.
f Cinders used in sidetracks only.
g Includes burned clay. Ballast varies from 3 in. in sand to 18 in. in clay.
h Includes burned gumbo. Depth of ballast varies from 6 in. to 12 in. with local conditions and variation in volume of traffic.
k Rock used on double and 4 track. Only 4-track section shown; sub-grade had transverse slope ¼ in. to 1 ft.
m Includes slag and disintegrated granite.
n Includes chats. Depth of ballast varies with nature of soil.
* Shoulder is dressed to bottom of tie in cementing gravel.
o Includes slag and disintegrating granite.
p Includes chats. Depth of ballast varies with nature of soil.
* Variation from standard made account of scant supply of ballast.
r Kind of ballast not stated. Standard not followed in sidetracks.

DISCUSSION.

(In the absence of the Chairman and Vice-Chairman of the Committee on Ballast, the report was presented by Prof. S. N. Williams, of Cornell College.)

Prof. S. N. Williams:—Your Committee has held two or three meetings during the year and appointed Sub-Committees to consider the different divisions of the work, continuing the work of the previous year.

The Sub-Committee on Revision of the Manual has made certain recommendations which are given in the body of the report. The first change is the use of the words "Stone Ballast" instead of the term "Broken or Crushed Rock."

With reference to the definition of the word "Sand," the recommendation of the Committee is that the definition adopted in 1909 be substituted for the one now appearing in the Manual. I presume these two points will have to be acted upon by the Association.

The Sub-Committee on Proper Thickness of Ballast has done much work in investigating the practice, not only of the American railways but also of the European railways—British, German and French—and the Committee also describes the practice of the American railways showing the depth of ballast used. In making its investigation into the practice of the European railways, the Sub-Committee accumulated considerable data, which has been summarized and will be found in the report.

The Sub-Committee on Gravel Ballast has made some investigation of that subject, and quite recently secured the results of extensive experiments made in Germany in reference to proper thickness of gravel ballast, but the translation of the manuscript giving the results of these experiments could not be made in time to be presented at this meeting. The Committee hopes, however, to have this available at a later date.

The President:—The Committee recommends that the report of Sub-Committee A, Revison of Manual, be adopted. We will therefore consider the report of Sub-Committee A, and the Secretary will read it.

The Secretary:—"Certain changes were made in the wording in the Manual in order to get the changes incorporated in the new edition.

"The term 'Broken or crushed rock' was changed to 'Stone Ballast,' inasmuch as stone seems to be the most common expression used by railroad men in speaking of ballast of this nature.

"Paragraph 2 was changed so as to combine 'A' and 'B' to read as follows:

"It shall be broken into pieces of such size that they will, in any position, pass through a 2½-in. ring and will not pass through a ¾-in. ring.

"It shall be free from dirt, dust or rubbish."

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I think consistency in our Manual is something we should endeavor to secure, and I see no reason for the insertion of the clause, "it shall be free from dirt, dust or rubbish," especially with regard to dust. Dust will certainly pass through a ¾-in. screen. I think that clause should be amended so as to read that it shall be free from foreign matter.

Mr. C. A. Morse (Santa Fe) :—I agree with Mr. McDonald on that point, for the reason that you might have rock with dust in it that would go through a ¾-in. ring, but there are roads in the country that do not make a practice of screening their ballast and they might pass an inspection something like that, but I think that would give the sense of the Association that ballast should be screened.

Another point in connection with this, regarding this upper size of the 2½-in. ring, I would rather have it ¾ than 2½. We are paying money to get crushing outfits to get stone smaller than 2½, in some cases 1½ in. I think there are many roads trying to get 1½-in. ballast. I do not think 2½-in. represents the best practice at the present time.

Prof. Williams:—The Committee a year ago made a thorough investigation, to obtain the results of the practice from different railways throughout the country, and found a large majority of 37 reporting were using that dimension, hence for this reason we incorporated it into our report as being preferred practice of the majority of roads which reported positively in favor of that limit. About one-half gave the maximum as stated—that was the reason the Sub-Committee recommended it and it was afterwards adopted by the Association. We found a difference of opinion in reference to the range of size, but that seemed to be the prevailing preference.

The President:—We will first consider changing the term "broken or crushed rock" to "stone ballast." If there is no discussion on that subject the recommendation of the Committee will be accepted.

We will proceed to the next item, the size of the stone, and take up that question.

Mr. J. M. Meade (Santa Fe) :—I want to say, as one of the members of the Committee, that I argued against the large-sized stone. It is almost impossible for sectionmen to surface track or even smooth it up with 2½-in. rock, and it is my judgment that that size should not be recommended. I would favor changing it to 1½-in. or even smaller.

Mr. McDonald:—I would ask if the Manual does not now provide for sizes of 2½ and ¾. I understand that the Committee has not proposed any changes in the size of the stone as it appears in the Manual.

The President:—That is the case.

Mr. McDonald:—Then the question before the convention, as I understand it, is whether we shall, without recommendation of the Committee, change these sizes.

The President:—The Manual at present says: "The maximum size of ballast shall not exceed pieces which will pass through a screen having 2-in. holes."

Mr. McDonald:—Then the Committee is making a radical change in the Manual.

Mr. Meade:—I think at the last convention there was a motion to change to 2½-in. stone.

Prof. Williams:—I understand this was approved by the Association a year ago.

Mr. W. M. Camp (Railway and Engineering Review):—But that action of a year ago was not indicated in the Manual?

The President:—The Manual has not been re-issued. This is an opportune time to make any change so that it may be incorporated in the new Manual.

Mr. McDonald:—I move that the wording of the clause regarding the size of the stone, as presented by the Committee, be retained with the exception that the dimension of 2 in. be restored, as it formerly appeared in the Manual.

Mr. C. A. Morse:—I would amend that to reduce the lowest size to ⅝-in., making it 2 in. for the maximum and ⅝-in. for the minimum.

Mr. McDonald:—I hardly feel that we ought to go that low. I think that one of the principal matters to be considered in the purchase of ballast is the question of commercial sizes, and if you get the size down so small as that, you will render the amount of screening derived from it so small that there will be very little money in getting out the ballast. I prefer to retain the sizes as 2 in. and ¾-in.

The President:—The question is on the higher limit of 2 in.

Prof. Williams:—The Committee would like an expression on this point. It seemed doubtful a year ago, when we made a like report as to what was really preferred by the members, considering all the circumstances involved, and our report seemed the preference of the majority who reported to us. It is a matter of practice of the railway companies which should be decided by them, hence we would like a full expression of opinion.

Mr. W. H. Courtenay (Louisville & Nashville):—In response to that request, I express the opinion that the 2½-in., as specified by the Committee, should remain; we should not change it. I think they have stipulated the best maximum.

Mr. M. L. Byers (Missouri Pacific):—We recently had an experience that suggests one or two remarks on this upper limit. In the first place, I think you can separate the stone ballasted track into two classes, the first being the track for passenger service. In that case you want a clean ballast—ballast that will give the minimum amount of dust. There is a great deal of track to which that argument does not apply with any very great force. There is much track in which you are not particularly interested in securing freedom from dust, but you are interested in maintaining the permanence of the position of your track. We have been obliged to do considerable re-ballasting work on a lot of track which was thinly ballasted with very coarse broken stone. I think the specification as to the upper limit probably was that the stone must go between it is hard to get any accurate surface, and yet, by filling in with smaller material and raising it sufficiently to put the coarse rock down below the bottom of the tie, we have practically formed a macadam surface in which the ballast below the bottom of the tie has become practically a solid mass, and above the bottom of the tie, and perhaps for an inch below the bottom, we have a fine material which can be cheaply worked. (I think it is fairly well-known to all of us that a man can put in a great many more ties per day in gravel ballast than in stone ballast, one reason being he has a finer material to work with and another being the usual difference in the character of the section.) For track over a soft sub-grade I am inclined to think there is no very material necessity for the 2½-in. upper limit. Our experience shows that we can use 6-in. stone to very good advantage, provided there is mixed with that 6-in. stone a finer material, just as in building a macadam highway. That distributes the pressure from the tie to the sub-grade to good advantage, and that is one of the principal objects of using the ballast. So I am inclined to think that in our discussion we should keep clearly in view the two requirements: first, the stone ballast for important passenger lines, where it is desirable to eliminate dust, and, second, where we simply wish to have ballast for the purpose of distributing the pressure from the tie to the sub-grade, and consequently where we want as solid a combined material as we can get.

Prof. Williams:—In our investigation we found that the Pennsylvania Lines, Baltimore & Ohio and some others are using large sizes, up to 3 in., and that the lines of great passenger traffic were favoring the larger rock, 2½ or 3 in., so we made it 2½ in.

Mr. C. A. Morse:—In regard to the question of size of ballast, if we could have ideal conditions there is no question but we could use from 2½ to 4 in. ballast, using the coarse stone for the first lift, but it has not been found practicable to handle it in this way. In the last lift it is desirable to use fine ballast. It seems to me that in discussing this subject thought is only being directed to original ballasting, which is only a small part of the ballast used. The advantage of smaller ballast when you surface the track out of face is that, whereas with 2½-in. stone you will have to make a raise of about 3 in., with 1½-in. stone you will only have to raise the track in re-surfacing about 2 in.

Mr. M. L. Byers:—I think that difficulty can be practically avoided by the unloading of the ballast in two different unloadings. We have tried that method with success—it means unloading enough coarse ballast to raise the track up to within practically an inch of the final grade, raising the track roughly on that ballast. Then follow that with finer material, unloaded from a center dump Rodger ballast car, and finish the raising and ballasting of the tracks with that finer material, so as to place the finer material on top.

Mr. C. E. Lindsay (New York Central & Hudson River):—It must be borne in mind that in reducing the maximum size of ballast you add to the cost. While our specifications are 2 in., we buy 2½-in. The stone that is larger than the maximum has to be re-elevated, and again passed through a crusher with a consequent amount of additional waste, and therefore the manufacturer of that ballast seeks a larger compensation. A reduction in maximum size increases the amount re-crushed. It would be interesting if the Committee would determine the percentages of the different sizes of stone that obtain—what proportion of a given quantity of ballast is of the different sizes, varying by half inches—how much 2½-in. stone, how much 2-in., how much 1½-in. and how much 1 in. The ballast is not all 2½-in. stone or all ¾-in. stone. It is a mixture, depending on the permissible sizes and the character of fracture of the rock. In my experience with limestone and trap rock we do not find, with 2½-in. stone, there is any difficulty in keeping the track in first-class alinement.

Mr. R. N. Begien (Baltimore & Ohio):—I do not believe it would be feasible or proper to put a limit on the size of ballast. We have maintained track on 2½-in. and 3-in. stone and secured good results with both sizes.

The President:—Is there any further discussion on the question of the maximum size of 2½ in.?

Mr. C. H. Stein (Central of New Jersey):—I note the Committee says: "Of such size that they will in any position pass through a 2½-in. ring." I believe it would be very hard to secure from the rock quarries such stone as would pass in any position through a 2½-in. ring. On account of the fracture of some rock, a great deal of the ballast is somewhat slabby; while it may have a thickness and breadth of only 2 in., it may be 3 or 4 in. in length. You will find a considerable proportion of such ballast that will not pass through a 2½-in. ring in every position, although it may be good ballast, and one can raise the track with a light lift of ½ or ¼ of an inch in a satisfactory manner. I do not believe that that provision of the specifications could be fulfilled that proposes that the ballast should pass through a 2½-in. ring in any position without excessive expense.

The President:—A previous provision on this subject was: "The maximum size shall not exceed pieces which shall pass through a 2½-in. test ring in any direction." That is practically the same meaning as recommended by the Committee this year.

Mr. Begien:—In setting a maximum size of ballast, it should be clearly understood that it is not necessary in the use of 2½-in. ballast to use all 2½-in. stone on which to raise the track. The section foreman in cleaning out would select a smaller size stone—he would probably use a smaller stone to make up a ¼ or ½-in. raise.

Mr. W. J. Bergen (New York, Chicago & St. Louis):—I would say that the change suggested is principally for the purpose of correcting the language. On close reading it will be found that the intention of the present recommendation is exactly that adopted by the previous convention. With regard to eliminating these long pieces, I should say that it is clearly the intention of the Committee to eliminate them. If you specify 2½-in. ring, without saying, in any possible direction, you are likely to get long scaly pieces, which will powder and will not make good ballast.

Mr. Meade:—It seems to me if the different railways that are represented here would state what their specifications are, we would have a better understanding of this question. We have heard from a very few, and we would like to know from the principal roads which are using crushed ballast, what their specifications are.

The President:—For the information of the Association, I will state that considerable correspondence was had with the roads on this subject last year, so that the practice of the railways was pretty well determined by the Committee which formed these recommendations, but we would like to hear from any of the members present on this subject.

Mr. G. W. Merrell (Norfolk & Western):—Our specifications provide for a maximum size of 2½ in. I think a better surface can be maintained with less labor with a 2-in. maximum.

Prof. Williams:—The Committee one year since made an earnest effort to secure information regarding practice of all the railways represented in the Association. We sent out over a hundred circular letters, but had replies from only about forty railways. These companies either gave their specifications or stated their practice quite fully, and their replies were carefully edited in the Proceedings, so that we have a fair expression of opinion of the different companies.

Mr. C. A. Morse:—On this question of ballast specifications they remind me of the size of track spike used, which, when I began work in 1880, was 5½ by 9/16 in., and to-day it remains the same. The first specifications for stone ballast that I ever saw called for 2½-in. stone, and on most roads they appear to have remained the same for about twenty-five years. I do not think that is any indication that this is the best size, however.

Mr. Jos. O. Osgood (Central of New Jersey):—I have very strong doubts whether many of the roads in the country which use stone ballast are getting a ballast which will answer this specification. Two and one-half inch stone is frequently mentioned for ballast and is generally used, but I doubt whether it ever meets this requirement without being much smaller than what we are accustomed to call 2½-in. stone. The difficulty is that in screening the stone it passes through a screen which has holes of a definite size and there is no possible way of getting the stones so arranged that they will be screened in every dimension. The result is when you get the stone, even that which has been carefully screened in accordance with the best practice, it comes out with some longer pieces. which will not pass crosswise through the ordinary mesh of the screen. I do not know how you are going to prevent that, and if you are going to use this specification and enforce it literally you will not have a 2½-in. stone, but nearer a 1½-in. stone.

Mr. Camp:—I think Mr. Osgood is right about that. The idea of specifying that the stone must be put through the ring in any position is that if some pieces are found that will not go through, the crusher is to be set to break the material a little finer, in which case, of course, the largest pieces will not only be smaller, but there will also be a larger proportion of fine material and dust.

The President:—We will now pass to the lower limit of ¾-in. Mr. Morse, do you make a motion to change that to ⅝-in.?

Mr. C. A. Morse:—I move that we change it to ⅝-in. diameter.

Mr. Earl Stimson (Baltimore & Ohio):—I think it would be a mistake to lower the minimum size below ¾ of an inch. We have found that for the harder stones, such as trap rock and granite, the ¾-in. minimum size, and for the softer stones that break up easily under tamping, such as lime and sandstones, the 1-in. minimum size give the best results.

Mr. G. D. Brooke (Baltimore & Ohio):—There is one thing to be considered in connection with this minimum size; that is, the effect of cleaning the ballast afterwards. If the minimum size is too small, a great deal of the fine stone will pass through the fork, in cleaning, and it will be loaded with the dirt or thrown down the bank. Large quantities of ballast are bought by weight. Of course, we pay as much for the fine stone as for the large, and we get the use of the fine stone only for two, three, four or five years, and then it is thrown away. It will be readily seen the waste will amount to a great deal.

The President:—Any further discussion on changing from ¾ to ⅝ in.? This is an important change, gentlemen.

Mr. George W. Kittredge (New York Central & Hudson River):—I shall vote against that amendment. A ⅝-in. ring would be all right for trap rock, and very hard stones of that kind, but for the majority of cases ¾-in. should stand. There are many limestones that are good in the ¾-in. size, which would not be so in a smaller size; they would pulverize and become dusty. I think the limit of ¾-in should stand.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I am going to vote in the negative because, as I read the report, this is simply a re-wording of the Manual, and is not a recommendation. It seems to me it would be better, if the convention desires a change in the standard specifications, to refer the question back to the Committee and let it bring in a revision next year. This is not a recommendation, as I read it, but simply a re-wording of that which the convention has already approved.

Mr. Meade:—I will say for the information of the last speaker, that this is the third year this Committee has had hold of this matter, and it seems to me they ought to dispose of it now.

(The motion was lost.)

Mr. McDonald:—I move that the words "dust, dirt and rubbish" be stricken out, and the words "foreign matter" be substituted in the next line.

Prof. Williams:—The Committee thinks the wording as now expressed is a little better for the average contractor, hence more likely to bring about better results than to express it differently, though members of the Association would understand the other fully, and the object is to have it entirely plain.

Mr. C. E. Lindsay (New York Central & Hudson River):—Mr. McDonald is right in saying the ¾-in. hole would take out all the dust, but after the stone has been screened and passes into the bins, each size to its particular bin, the contractor allows the dust bin to fill up and run over into the other bin. I recently rejected some cars of stone on the ground that there was dust in it from this cause, and think the clause should remain in the specification.

The President:—I will read the action of the Association last year upon this subject:

"The maximum size shall not exceed pieces which will pass through a 2½-in. test ring in any direction. The minimum size shall not pass through a ¾-in. test ring, and the rock shall be free from dust, dirt and rubbish."

Mr. G. J. Ray (Delaware, Lackawanna & Western):—It seems to me that dust would not be foreign matter; it is a part of the original stone. It certainly is not foreign substance.

Mr. McDonald:—In making my motion I simply wanted our text to appear consistent. Mr. Lindsay has called attention to one manner in which dust can get around a ¾-in. ring, but I never heard of that case before; but if you say the ballast shall consist of material that will pass through a ¾-inch ring, it seems to me to go along further and say dust shall be excluded, is inconsistent. I believe it is the desire of the members that the printed matter be at least consistent, and I simply arose with a view of straightening out this feature of the Committee's report, so that it can appear properly in the Manual.

Mr. Begien:—I think it would be necessary to describe what "foreign matter" means. In receiving ballast, the main objection is generally the introduction of soft stone. There are few quarries that have all one kind of stone in them. I know that in trap rock quarries it is not unusual to find granite pockets, and even flint. There is no provision made here to exclude soft stone.

Mr. McDonald:—We have already described, in previous specifications, what the stone shall stand per square inch, in compression. In order to define what I meant by foreign matter I will state that I mean matter which is not stone. The specifications say it shall be stone, but it does appear that we have opened a new question, and with the consent of my second I will withdraw my motion.

The President:—We will now proceed to the next item, "Gravel, Cinders and Burnt Clay Ballast" has been changed to read "Gravel, Cinder and Burnt Clay Ballast." Is there any objection?

Mr. Wendt:—I will say for the information of the Association that these changes have all been made and are in print. The specifications under this head have already been printed and are just ready to be issued.

The President:—The convention accepts the wording as it is now. The next subject is the question of changing gravel ballast to gravel. I assume your remarks applied to that, Mr. Wendt. The Committee is willing to let that stand as now set up. The matter in the Manual is largely in type and to make any small changes that have no essential effect on the meaning or import would cost considerable money, and I do not believe any of us will be so technical, unless it is a matter of importance, to require it. The same will apply to cinder ballast, to be changed to "cinders." The Committee is willing to let that stand. The definition for sand is the same as adopted in 1909, so that unless there is some objection to that definition we will accept it as submitted by the Committee. The Committee offers no recommendation for adoption other than those submitted in Sub-Committee A's report, Revision of Manual. Report of Sub-Committee B is simply submitted as a progress report. The other Sub-Committees' reports are submitted as matters of information, excepting the recommendation that has been read by the Committee this morning on the subject of gravel ballast. The Sub-Committee further recommends that investigations or tests be made, the expense of which to be borne by the Association, which would determine if possible the distribution of the stress in the ballast from the bottom of the tie to the bottom of the ballast, and on to the sub-grade. I think this is a matter that can be properly referred to our Board of Direction in the assignment of work to the Committee, and it requires no action of the Association.

Prof. Williams:—I move that the recommendations of the Committee be adopted.

(The motion was carried.)

The President:—Before dismissing the Committee, the chair would state that a telegram has been received from Mr. John V. Hanna, the chairman of the Committee, regretting his inability to be present.

If there is no further discussion on the report of the Committee, it will be relieved with the thanks of the Association.

REPORT OF COMMITTEE III.—ON TIES.

(Bulletin 131.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The Board of Direction assigned the following subjects to the Committee:

(1) Consider revision of the Manual.

(2) Continue compilation of statistics on life of treated and untreated ties. Digest the statistics and present conclusions derived therefrom.

(3) Metal, composite and concrete ties.

(4) Make concise recommendations for next year's work.

At the first meeting of the Committee on April 29, 1910, sub-committees were appointed to consider and report on the foregoing subjects, as follows:

Sub-Committee A—Revision of the Manual:
E. E. Hart, Chairman.
W. F. H. Finke.
G. W. Merrell.

Sub-Committee B—Statistics:
L. A. Downs, Chairman.
F. G. Jonah.
Edward Laas.

Sub-Committee C—Metal, Composite and Concrete Ties:
W. F. H. Finke, Chairman.
H. S. Wilgus.
E. D. Jackson.
F. R. Layng.

Sub-Committee D—Use of Cypress as Tie Timber:
F. G. Jonah, Chairman.
A. F. Dorley.
H. C. Landon.

The Sub-Committee on Revision of the Manual has no recommendations to make for changes in the present version.

Under Appendix A will be found the report of the Sub-Committee on Cross-Tie Statistics.

Supplementing its previous reports on the subject of metal, composite and concrete ties, the Committee presents the results of its investigations in Appendix B.

The increased use of cypress as cross-tie timber has led the Committee to make some inquiries into the subject, and the result of its efforts are given in Appendix C.

As a matter of interest the Committee submits some information on the subject of abrasion of cross-ties by track rails; this data will be found in Appendix D, and is submitted for the information of the members of the Association and for discussion.

CONCLUSION.

Your Committee has no recommendations to offer for adoption, and respectfully presents this report as a report of progress.

Respectfully submitted,

E. E. Hart, Chief Engineer, New York, Chicago & St. Louis Railway, Cleveland, Ohio, *Chairman*.

W. F. H. Finke, Tie and Timber Agent, Southern Railway, Washington, D. C., *Vice-Chairman*.

A. F. Dorley, Division Engineer, Missouri Pacific Railway, Kansas City, Mo.

L. A. Downs, Superintendent, Illinois Central Railroad, Fort Dodge, Iowa.

W. F. Goltra, Cleveland, Ohio.

E. D. Jackson, Division Engineer, Baltimore & Ohio Railroad, Garrett, Ind.

F. G. Jonah, Chief Engineer Construction, St. Louis & San Francisco Railroad, St. Louis, Mo.

H. C. Landon, Division Engineer, Erie Railroad, Hornell, N. Y.

Edward Laas, Los Angeles, Calif.

F. R. Layng, Engineer of Track, Bessemer & Lake Erie Railroad, Greenville, Pa.

G. W. Merrell, Assistant to General Manager, Norfolk & Western Railway, Roanoke, Va.

L. M. Perkins, Engineer Maintenance of Way, Northern Pacific Railway, St. Paul, Minn.

H. S. Wilgus, Engineer Maintenance of Way, Pittsburg, Shawmut & Northern Railroad, Angelica, N. Y.

Committee.

Appendix A.

STATISTICS OF CROSS-TIES.

The Sub-Committee to which the subject of collection of Statistics of Cross-Ties was assigned, issued the following circular of inquiry:

"In endeavoring to collect data relative to statistics of cross-ties, the Committee on Ties has concluded that few railroad companies, if any, have complete or reliable information concerning the life of ties. Most railroad companies have good records of renewals of cross-ties each year, and, in many cases, keep such records by miles.

"It is believed that the approximate life of ties can be arrived at in the case of new track, built within the last ten or fifteen years, the number of ties originally placed in the track being known and also the total number in the whole length of track and the number taken out of track each year.

"During the past ten years you have probably built extensions of some kind, or built new second track, or had grade reduction work where certain kinds of ties, either treated or untreated, have been put in out of face It is immaterial if the track is one mile or 200 miles in length. Information of this character is what the Committee desires.

"Enclosed herewith is a blank form which can easily be filled out, giving the year the ties were laid, the number removed each year to date and the kind of ties used, whether treated or untreated.

"Date constructed; between what two cities or towns; state; length of track in miles; number of ties per mile; total number of ties; kind of ties; number of ties used in renewals, according to years, as follows: 1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910."

The replies received in answer to this circular have been tabulated and are given in Table 1.

In addition to the tabulation, some interesting data was received from the Chicago & Eastern Illinois Railroad and from the Atchison, Topeka & Santa Fe Railway. This information is given in Tables 2-8. Further information in reference to the Experimental Track in Texas, heretofore reported by this Committee, is contained in Table 9.

As a matter of interest, the following communication from Mr. George E. Rex, Manager of the Treating Plants of the Santa Fe Railway System, is quoted in full:

"I have your communication in regard to tie records and it is extremely interesting to me at the present time, as we are just starting a new system of tie records, and I have gotten out our records so that they will follow as closely as possible the outline of the Tie Committee's recommendation on records in the Manual.

"For years we have attempted to keep our record of ties on every section of track on the road; but with the class of help we get on this

TABLE 1—STATISTICS OF CROSS-TIES.

Railroad	Kind of Ties	Number	State	Year Laid
A. T. & S. F. Ry., Olinda Dist.	Burnettized Arizona Pine	11,827	California	1899
B. & O. R. R.	Oak	201,600	Ohio	1899–1900
Canadian Pacific R. R.	Tamarack	432,810	Saskatchewan	1891
Central Railroad of N. J.	Oak, Yellow Pine, Chestnut	4,237,653	N. J. and Penna	Various
C. B. & Q. R. R.	Treated Black Oak	40,885	Illinois	1904
C. B. & Q. R. R.	White Oak	179,534	Illinois	1905
C. B. & Q. R. R.	White Oak and Cypress	242,328	Missouri	1903–1904
C. B. & Q. R. R.	Tamarack, Cedar, Pine	329,774	Nebraska	1905–1906
C. B. & Q. R. R.	Treated Pine and Fir	313,808	Wyoming	1906
C. B. & Q. R. R.	Treated Pine, Fir, Untreated Pine, Fir, Cedar	430,300	Wyoming and Montana	1901
Chicago, Indiana & Southern	Red and White Oak	55,500	Illinois	1899
C. M. & St. P.	Yellow Pine	7,500	Iowa	1900
C. R. I. & P.	White Oak	101,700	Texas	1903
C. R. I. & P.	Cypress, Gum, W. Oak, Pine	175,500	Louisiana	1907
C. R. I. & P.	White Oak	318,100	Arkansas	1906–1907
C. R. I. & P.	White Oak	137,200	Arkansas	1907
Duluth & Iron Range	Tamarack	7,500	Minnesota	1902
Erie Railroad	Oak	8,605	Ohio	1903
Ft. Smith & Western	Oak, Yellow Pine	694,300	Oklahoma	1901–1902
Ft. Worth & Denver City	Pine	1,433,248	Texas	
Grand Rapids & Indiana	Oak, Cedar	11,117	Michigan	1898
Grand Trunk System	Cedar	83,200	Canada	1900
Hocking Valley	White and Mixed Oak	1,075,700	Ohio	1874–76–81
Illinois Central		*10,607	Iowa	
Illinois Central		9,826	Minnesota	
Illinois Central	Chestnut	21,280	Kentucky	1905–1906
Illinois Central	Red Oak	51,200	Tennessee	1903
Illinois Central	Red Oak	22,400	Tennessee	1905
Illinois Central	Red Oak	38,400	Tennessee	1904
Illinois Central	Red Oak	48,000	Tennessee	1903
Illinois Central	White Oak	351,600	Iowa	1899
Lake Shore & Mich. Southern	White Oak	369,600	Indiana, Michigan, Ohio	1833–1862
Lake Superior & Ishpeming	White Oak	57,000	Michigan	1896
Louisiana & Arkansas	White and Post Oak	93,900	Louisiana	1903
Louisville & Nashville	White Oak	24,920	Kentucky	1895
Memphis, Helena & Louisiana	Cypress, Red and White Oak	236,160	Arkansas	1905
Missouri Pacific Ry				
Missouri Pacific Ry	Oak	118,400	Louisiana and Arkansas	1906
St. L. I. M. & S.	White Oak	342,400	Missouri and Arkansas	1905
Mobile & Ohio	Oak	646,631	Miss. and Alabama	1897
Mobile & Ohio	Pine	646,631	Miss. and Alabama	1897
Miss. River & Bonne Terre	White and Post Oak	9,758	Missouri	1902
N. Y. C. & H. R. R. R.	Yellow Pine	14,688	New York	1903
N. Y. C. & H. R. R. R.	White, Rock, Red Oak, Chestnut	150,048	Pennsylvania	1901–1902
P. & R.	White Oak	16,915	Pennsylvania	1901
P. & R.	Yellow Pine	21,805	Pennsylvania	1901
P. & R. (Little Schuylkill and Navigation)	Oak and Chestnut	5,760	Pennsylvania	1897
P. & R.	Chestnut	2,816	Pennsylvania	1903
Penna. Lines West	White Oak	127,902	Ohio	1892
Pgh. Shawmut & Northern	White Oak, Yellow Pine	20,219	Pennsylvania	1902
Pgh. Shawmut & Northern	White Oak, Yellow Pine	32,256	Pennsylvania and N. Y.	1909
Pgh. Shawmut & Northern	White Oak, Yellow Pine	65,725	New York	1902
Rutland Railroad	Cedar, Tamarack, Hemlock, Spruce and Pine	110,880	Vermont	1899–1900
Texas Midland	Oak	375,000	Texas	1882–1894–96
T. & N. O.	Hemlock, Cedar and Tamarack	397,440	Ontario	1903–1904
Uintah Ry		153,000	Colorado	1904–1905
Washington Terminal	White Oak and Yellow Pine	137,000	District Columbia	1904–1906

* To August 1st.
† To August 1st. Records prior 1908 destroyed by fire.

TABLE 1—STATISTICS OF CROSS-TIES—CONTINUED.

NUMBER OF TIES REPLACED FOR THE YEARS

1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
......	......	......	......	......	......	......	......	......	1,014	996	1,096	3,202	2,077	2,411	780
......	......	......	......	......	......	......	......	......	3,864	4,276	12,173	22,034	17,671	34,697	......
......	......	865	2,160	4,320	22,000	41,488	60,936	64,394	59,072	64,825	53,156	37,167	67,086	67,086	......
......	......	......	......	....	354,018	345,991	347,595	263,922	450,545	403,405	265,617	264,553	297,978	408,942	......
......	......	......	......	......	......	......	......	......	......	......	17	478	178	761	323
......	......	......	......	......	......	......	......	......	......	......	41	105	1,641	1,556	5,256*
......	......	......	......	......	......	......	......	......	......	......	165	1,021	4,026	15,009	23,520*
......	......	......	......	......	......	......	......	......	......	......	......	2,820	33,414	3,225	17,673†
......	......	......	......	......	......	......	......	......	......	......	......	......	2,986	586	1,968†
......	......	......	......	......	......	......	......	......	......	......	......	......	9,649	21,607	18,502†
......	......	......	......	......	......	......	......	......	......	......	13,011	6,971	5,088	5,585	......
......	......	......	......	......	......	......	......	......	......	......	695	695	695	695	345
......	......	......	......	......	......	......	......	......	......	......	......	27,608	38,424	22,162	5,782
......	......	......	......	......	......	......	......	......	......	......	......	......	......	19,108	12,431
......	......	......	......	......	......	......	......	......	......	......	......	12	3,205	17,367	19,350
......	......	......	......	......	......	......	......	......	......	......	......	......	640	5,216	5,254
......	......	......	......	......	......	......	......	......	......	......	......	......	460	2,420	2,630
......	......	......	......	......	......	......	......	......	......	......	515	1,899	250	1,023	265
......	......	......	......	......	......	......	......	......	......	......	26,090	59,768	116,400	78,655	......
......	......	......	156,455	149,989	202,075	231,320	100,656	213,808	200,236	130,717	159,432	314,128	318,948	308,907	120,365
......	......	......	......	......	......	......	......	......	......	......	......	......	1,750	1,700	600
......	......	......	......	......	......	......	......	......	......	......	......	......	800	1,760	2,500
118,400	110,400	135,450	126,311	......	137,900	152,000	124,700	120,000	135,300	150,000	134,500	126,300	104,000	199,090	155,665
......	......	......	......	......	......	......	......	1,243	......	1,556	592	1,397	1,809	2,690	1,320
......	......	......	......	......	......	......	......	......	......	......	......	632	1,375	4,350	3,469
......	......	......	......	......	......	......	......	......	......	......	......	......	2,102	4,137	10,662
......	......	......	......	......	......	......	......	......	......	......	......	......	82	1,342	458
......	......	......	......	......	......	......	......	......	......	......	......	......	257	342	1,809
......	......	......	......	......	......	......	......	......	......	......	......	......	1,350	2,134	1,824
......	......	......	......	......	......	......	......	......	......	......	......	......	838	1,469	1,252
......	......	......	......	......	......	88	450	250	5,922	36,073	24,556	16,994	36,232	11,356	42,550
......	......	......	......	......	......	38,196	39,676	33,620	31,495	28,724	33,473	47,253	40,650	64,789	38,000
......	......	......	......	......	......	......	......	3,008	4,464	5,866	9,095	15,195	10,154	6,459	2,759
......	......	......	......	......	......	......	......	......	80	55	65	2,524	12,152	23,828	13,450
......	......	......	......	......	......	1,200	5,549	3,652	1,487	3,628	3,873	4,825	3,821	2,112	2,479
......	......	......	......	......	......	......	......	......	......	......	400	2,100	36,550	74,175	33,180
......	......	......	......	......	......	......	......								
......	......	......	......	......	......	......	......	......	......	......	......	......	3,145	6,725	20,378
......	......	......	......	......	......	......	......	......	......	......	......	510	5,384	24,058	39,810
......	......	......	......	......	1,204	8,954	43,951	45,905	43,124	48,904	35,001	69,732	70,248	58,836	56,637
......	......	......	......	......	6,341	12,521	48,131	60,989	54,408	50,092	26,843	24,148	21,649	45,446	14,126
......	......	......	......	......	......	......	......	......	......	181	354	233	328	1,532	479
......	......	......	......	......	......	......	......	......	300	400	200	100	200	100	500
......	......	......	......	......	......	......	2,086	9,201	11,696	15,292	15,296	34,342	30,688	33,686	10,007
......	......	......	......	......	......	......	......	......	......	......	734	2,806	4,360	5,770	2,200
......	......	......	......	......	......	......	......	......	......	......	......	210	1,153	1,729	6,340
......	......	......	......	......	......	......	......								
......	......	......	......	......	......	......	......	......	......	364	546	1,325	1,475	800	760
								......	......	......	......	......	......	1,876	470
......	......	......	10,057	8,973	15,104	17,872	13,389	34,481	10,594	10,670	10,223	9,254	5,230	9,965	9,115
......	......	......	......	......	......	......	......	......	......	......	......	......	......	234	569
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	81	95	953
......															
......	......	......	......	......	......	......	......	......	......	......	5,785	21,506	16,256	10,393	7,647
	......	......	56,539	51,677	68,725	92,844	40,785	43,764	38,371	40,888	43,464	46,708	56,225	65,205	59,187
......	......	......	......	......	......	......	......	......	......	......	......	3,390	10,123	35,192	60,925
......	......	......	......	......	......	......	......	......	......	......	106	498	421	689	2,372
......	......	......	......	......	......	......	......	......	......	......	......	......	......	1,194	3,213

work it seems almost impossible to get an accurate record, and for this reason we discontinued this method and pick out experimental sections on each Division Superintendent's division, taking an actual inventory of the ties in the track and all other information that would be of value and then make an annual inspection of each one of these sections and have monthly reports made of ties taken out and put in. This, we hope, will in time give us an absolute record of the life of our ties.

"The best information I can furnish you, however, is a copy of our last annual statement, which may be found of interest, and I am sending also a copy of the record of experimental ties put in by the Forest Service on our experimental track in East Texas in 1902, worked out in percentages, so that an accurate idea of the results can be had at a glance."

TARLE 2—ZINC-TREATED TIES TAKEN UP YEAR 1909.

Chicago & Eastern Illinois Railroad Company.

	Decayed.	Burned.	Wreck.	Split.	Total.
Chicago Division	2048	34	694	19	2795
Illinois Division	2896	164	405	61	3526
Grand Total	4944	198	1099	80	6321

Zinc-treated Ties put in:		Zinc-treated Ties Taken Out:	
1899	25,477 ties	1899	....
1900	205,521 "	1900	30 ties
1901	170,875 "	1901	1,890 "
1902	130,313 "	1902	484 "
1903	75,398 "	1903	787 "
1904	91,037 "	1904	718 "
1905	160,437 "	1905	2,019 "
1906	253,327 "	1906	2,527 "
1907	352,573 "	1907	8,450 "
1908	96,775 "	1908	4,977 "
1909	85,872 "	1909	6,321 "
Total	1,647,605 "	Total	28,203 "

TABLE 3—CREOSOTED TIES TAKEN UP YEAR 1909.

Chicago & Eastern Illinois Railroad Company.

	Decayed.	Burned.	Wreck.	Split.	Total.
Chicago Division	....	...	...	..	....
Illinois Division	....	...	2	..	2
Grand Total	....	...	2	..	2

Creosoted Ties Put In:		Creosoted Ties Taken Out:	
1908	143,894 ties	1908	....
1909	93,798 "	1909	2 ties
Total	237,692 "	Total	2 "

TABLE 4—STATEMENT SHOWING TIES INSERTED FROM 1898 TO 1909, INCLUSIVE.

THE ATCHISON, TOPEKA & SANTA FE RAILWAY COMPANY.

Eastern Lines—Eastern District.

Year	Chicago Division		Illinois Division		Missouri Division		Kansas City Division		Eastern Division		Total, Eastern District		Total, Eastern and Western Lines	
	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile
1898	215,026	375							120,940	354	335,966	367	1,277,008	283
1899	68,509	119							158,757	395	227,266	233	1,316,195	289
1900	56,662	99							118,175	294	174,837	179	1,188,118	249
1901	127,108	221							86,510	215	213,618	219	1,075,041	225
1902	419,556	731							143,080	354	562,636	678	1,666,053	339
1903			145,177	506	128,002	446			204,552	506	477,731	489	1,823,161	371
1904			99,520	346	150,780	520	91,253		213,634	537	555,187	562	2,008,774	407
1905			254,027	882	198,652	685	38,223		241,101	607	732,003	740	2,285,915	463
1906			214,664	738	147,853	510	32,638		138,767	350	533,922	538	1,507,186	305
1907			338,796	1,164	217,590	750	15,126		240,998	607	812,510	819	2,330,937	452
1908			251,644	865	218,536	754	13,407		198,371	476	681,958	674	2,475,586	478
1909			178,058	612	220,357	760	22,348		180,517	433	528,932	523	2,484,797	447

TABLE 5—STATEMENT SHOWING TIES INSERTED FROM 1898 TO 1909, INCLUSIVE.

THE ATCHISON, TOPEKA & SANTA FE RAILWAY COMPANY,

Western Lines

Year	Pan Handle Division		Western Division		Ark. River Division		Colorado Division		New Mexico Division		Rio Grande Division		Total, Western Lines		Total, Eastern and and Western Lines	
	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile
1898			78,010	183					154,082	403	96,253	235	328,345	270	1,277,008	283
1899	36,500	80	114,421	269					150,269	393	96,219	233	397,409	237	1,316,195	289
1900	154,012	257	116,063	276					170,444	446	91,646	218	532,165	292	1,188,118	249
1901	92,289	166	73,779	119			132,281	578	121,697	319	51,732	123	471,778	214	1,075,041	225
1902	95,966	155	102,273	165			58,642	212	214,819	562	60,831	145	532,531	235	1,666,053	339
1903	104,591	169	157,678	254			61,568	269	164,686	431	110,843	264	599,366	264	1,823,161	371
1904	176,844	287	210,271	340			75,771	335	161,078	398	144,733	342	768,697	336	2,008,774	407
1905	184,847	300	299,312	484			82,108	363	189,033	470	136,092	322	891,392	390	2,295,915	463
1906	110,600	179	199,790	323			66,144	293	104,113	259	125,151	296	605,798	265	1,507,186	305
1907	210,677	297	212,394	512	188,188	927	87,288	390	148,639	400	144,601	342	991,787	423	2,330,937	452
1908	357,326	503	226,123	545	135,417	667	87,971	393	183,259	493	170,778	404	1,160,874	495	2,475,586	478
1909	245,059	345	224,011	540	99,907	322	112,527	502	211,434	568	286,055	431	1,178,993	437	2,484,797	447

TABLE 6—STATEMENT SHOWING TIES INSERTED FROM 1898 TO 1909, INCLUSIVE.

ATCHISON, TOPEKA & SANTA FE RAILWAY COMPANY.

Eastern Lines—Western District.

Year	Southern Kansas Division		Middle Division		Oklahoma Division Incl. E. O. Ry.		Total, Western District		Total, Eastern and Western Lines	
	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile
1898	136,969	215	243,683	287	232,045	260	612,697	258	1,277,008	283
1899	172,137	265	253,109	300	266,274	656	691,520	364	1,316,195	289
1900	168,484	259	177,669	210	134,963	282	481,116	244	1,188,118	249
1901	152,959	233	164,123	384	72,563	151	389,645	249	1,075,041	225
1902	126,387	193	115,719	187	328,780	845	570,886	343	1,666,053	339
1903	194,919	297	127,169	206	423,976	1,090	746,064	451	1,823,161	371
1904	316,800	487	261,536	424	106,554	274	684,890	413	2,008,774	407
1905	241,191	365	300,878	488	120,451	310	662,520	397	2,285,915	463
1906	186,961	283	145,369	236	35,136	90	367,466	221	1,507,186	305
1907	248,662	376	195,987	318	81,991	152	526,640	290	2,330,937	452
1908	213,784	323	213,765	346	205,205	381	632,754	348	2,475,586	478
1909	229,415	347	211,499	343	336,008	582	776,872	419	2,484,797	447

TABLE 7—STATEMENT SHOWING TIES INSERTED FROM 1898 TO 1909, INCLUSIVE.

GULF, COLORADO & SANTA FE RAILWAY COMPANY.

Year	Northern Division		Southern Division		Beaumont Division		Galveston Division Incl. Terminals		Total, G. C. & S. F. Ry.	
	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile
1898	301,511	597	265,620	456					567,131	521
1899	311,222	616	236,294	408					547,516	505
1900	122,475	243	150,093	261			1,871	468	274,439	253
1901	129,841	321	130,982	228	3 Mos.20,143	132	1,599	400	282,565	249
1902	105,273	260	154,476	269	42,890	280	2,306	576	304,945	268
1903	167,228	413	189,338	329	90,883	594	3,564	891	451,013	397
1904	204,730	505	197,297	344	85,067	281	5,762	1,440	492,856	383
1905	177,330	437	176,942	396	98,230	324	6Mos. 61,068	273	513,570	372
1906	134,220	330	191,324	428	107,518	355	84,219	376	517,281	375
1907	143,345	352	192,576	431	152,341	426	137,230	613	625,492	436
1908	207,965	511	182,093	407	111,466	311	76,910	343	578,434	403
1909	195,366	479	237,752	533	107,228	277	71,735	305	612,081	414

TABLE 8—STATEMENT SHOWING TIES INSERTED FROM 1898 TO 1909, INCLUSIVE

THE ATCHISON, TOPEKA & SANTA FE RAILWAY COMPANY,

Coast Lines

Year	Albuquerque Divsioin Incl. GrandCanyon Ry.		Arizona Division		Los Angeles Division		Valley Division		Total, Coast Lines	
	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile	Ties Inserted	Average Per Mile
1898	265,091	639	360,593	925	304,098	624			929,782	719
1899	200,102	482	96,742	248	111,608	229			408,452	316
1900	137,897	332	61,601	158	27,513	56			227,011	176
1901	112,573	271	36,618	94	68,435	141	4,390	12	222,016	133
1902	114,075	238	104,020	252	61,207	128	4,012	11	283,314	162
1903	143,489	300	189,008	420	93,951	195	8,319	22	434,767	244
1904	162,739	340	248,836	536	125,427	262	11,849	31	548,851	304
1905	171,915	359	171,472	370	112,833	236	45,609	117	501,829	277
1906	219,406	456	233,711	475	166,037	347	109,297	279	728,451	395
1907	190,679	396	268,924	530	302,761	633	218,144	554	980,508	527
1908	150,040	312	90,442	178	307,880	644	327,519	831	875,881	471
1909	209,073	416	121,578	238	284,678	596	202,804	512	818,133	434

TABLE 9—RECORD OF LIFE OF TIES IN EXPERIMENTAL TRACK ON THE BEAUMONT DIVISION OF THE GULF, COLORADO & SANTA FE RAILWAY IN TEXAS.

Kind of Wood	No. of Ties	Kind of Treatment	Year Inserted	Nov. 1903		June 1904		Nov. 1905		Dec. 1906		Feb. 1908		Nov. 1908		Sept. 1909		Ties Still in Track	
				No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
White Oak	196	Untreated	May, 1902			1	0.5					146	75					49	25
White Oak	100	Burnett, Chicago	May, 1902															100	100
White Oak	101	Wellhouse, Chicago	May, 1902									3	3	2	5			96	95
White Oak	107	Zinc-Creo., Beaumont	May, 1902	45	42	36	75.7	26	100									0	0
White Oak	100	Burnett, A.& L. Somerville	May, 1902									17	17	1	18	82	100	0	0
White Oak	100	Wellhouse, A.& L. Somerville	May, 1902											42	42			58	58
White Oak	100	Allardyce, A.& L. Somerville	May, 1902											1	1	1	2	98	98
White Oak	196	Barschall, A.& L. Somerville	May, 1902					2	1	22	12.2	140	83.7					32	16.3
Red Oak	93	Untreated	March, 1902			5	5.4	77	88.2					5	93.5			6	6.5
Red Oak	86	Burnett, Chicago	March, 1902													3	3.5	83	97
Red Oak	20	Burnett, A.& L. Somerville	March, 1902													20	100	0	0
Red Oak	20	Wellhouse, A.& L. Somerville	March, 1902													20	100	0	0
Red Oak	10	Allardyce, A.& L. Somerville	March, 1902															10	100
Red Oak	19	Barschall, A.& L. Somerville	March, 1902					15	78.9	2	89.5			2	100			0	0
Black Oak	24	Untreated	May, 1902					3	12.5	19	91.7	2	100					0	0
Black Oak	86	Wellhouse, Chicago	May, 1902									12	14	2	16.3			72	84
Black Oak	76	Zinc-Creo., Beaumont	May, 1902	36	47.4	40	100											0	0
Black Oak	34	Burnett, A.& L. Somerville	May, 1902									5	14.7					29	85.3
Black Oak	33	Wellhouse, A.& L. Somerville	May, 1902									2	6	16	54.5			15	45.5
Black Oak	60	Allardyce, A.& L. Somerville	May, 1902															60	100
Black Oak	118	Barschall, A.& L. Somerville	May, 1902					104	88.1	4	91.5	3	94.1	7	100			0	0
Turkey Oak	20	Untreated	April, 1902							18	90					2	100	0	0
Turkey Oak	10	Zinc-Creo., Beaumont	April, 1902					10	100									0	0
Turkey Oak	19	Burnett, A.& L. Somerville	April, 1902													19	100	0	0
Turkey Oak	20	Wellhouse, A.& L. Somerville	April, 1902													18	90	2	10
Turkey Oak	10	Allardyce, A.& L. Somerville	April, 1902															10	100
Turkey Oak	19	Barschall, A.& L. Somerville	April, 1902					18	94.7	1	100							0	0
Spanish Oak	20	Untreated	May, 1902					4	20			16	100					0	0
Spanish Oak	10	Zinc-Creo., Beaumont	May, 1902					8	80									2	20
Spanish Oak	21	Burnett, A.& L. Somerville	May, 1902									5	23.8					16	76.2
Spanish Oak	20	Wellhouse, A.& L. Somerville	May, 1902															20	100
Spanish Oak	10	Allardyce, A.& L. Somerville	May, 1902															10	100
Spanish Oak	20	Barschall, A.& L. Somerville	May, 1902					1	5	8	45	11	100					0	0

TABLE 9—CONTINUED—RECORD OF LIFE OF TIES IN EXPERIMENTAL TRACK ON THE BEAUMONT DIVISION OF THE GULF, COLORADO & SANTA FE RAILWAY IN TEXAS.

Kind of Wood	No. of Ties	Kind o Treatment	Year Inserted	Nov. 1903		June 1904		Nov. 1905		Dec. 1906		Feb. 1908		Nov. 1908		Sept. 1909		Ties Still in Track	
				No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Willow Oak	20	Untreated	May, 1902	....	......	....	......	15	75	5	100	....	......	....	......	....	......	0	0
Willow Oak	11	Zinc-Creo., Beaumont	May, 1902	....	......	....	......	11	100	....	......	....	......	....	......	....	......	0	0
Willow Oak	20	Burnett, A.& L. Somerville	May, 1902	....	......	....	......	....	......	....	......	....	......	....	......	20	100	0	0
Willow Oak	20	Wellhouse, A.& L. Somerville	May, 1902	....	......	....	......	....	......	....	......	....	......	8	40	....	......	12	60
Willow Oak	10	Allardyce, A.& L. Somerville	May, 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	10	100
Willow Oak	20	Barschall, A.& L. Somerville	May, 1902	....	......	....	......	17	85	3	100	....	......	....	......	....	......	0	0
Beech	100	Untreated	Feb. 1902	....	......	....	......	97	97	3	100	....	......	....	......	....	......	0	0
Beech	50	Zinc-Creo., Beaumont	Feb. 1902	....	......	....	......	....	......	....	......	50	100	....	......	....	......	0	0
Beech	99	Burnett, A.& L. Chicago	Feb. 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	99	100
Beech	100	Wellhouse, A.& L. Chicago	Feb. 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	100	100
Beech	50	Allardyce, A.& L. Somerville	Feb. 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	50	100
Beech	98	Barschall, A.& L. Somerville	Feb. 1902	....	......	2	2	96	100	....	......	....	......	....	......	....	......	0	0
Hemlock	101	Untreated	April, 1902	....	......	101	100	....	......	....	......	....	......	....	......	....	......	0	0
Hemlock	49	Zinc-Creo., Beaumont	April, 1902	....	......	....	......	....	......	38	77.6	....	......	4	85.7	....	......	7	14.3
Hemlock	100	Burnett, Chicago	April, 1902	....	......	....	......	....	......	....	......	....	......	30	30	....	......	70	70
Hemlock	100	Wellhouse, Chicago	April, 1902	....	......	....	......	....	......	....	......	....	......	....	......	4	4	96	96
Hemlock	50	Allardyce, A.& L. Somerville	April, 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	50	100
Hemlock	100	Barschall, A.& L. Somerville	April, 1902	....	......	....	......	87	87	7	94	....	......	6	100	....	......	0	0
Tamarack	49	Untreated	May, 1902	....	......	....	......	49	100	....	......	....	......	....	......	....	......	0	0
Tamarack	51	Zinc-Creo., Beaumont	May, 1902	....	......	....	......	....	......	....	......	....	......	....	......	46	90.2	5	9.8
Tamarack	49	Burnett, Chicago	May, 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	49	100
Tamarack	100	Wellhouse, Chicago	May, 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	100	100
Tamarack	50	Allardyce, A.& L. Somerville	May, 1902	....	......	....	......	....	......	....	......	....	......	....	......	....	......	50	100
Tamarack	98	Barschall, A.& L. Somerville	May, 1902	....	......	....	......	78	79.6	....	......	11	90.8	....	......	....	......	9	9.2
Shortleaf Pine	100	Untreated	May, 1902	....	......	35	35	20	55	44	99	....	......	....	......	....	......	1	1
Shortleaf Pine	50	Zinc-Creo., Beaumont	May, 1902	....	......	....	......	....	......	....	......	....	......	43	86	....	......	7	14
Shortleaf Pine	100	Burnett, A.& L. Somerville	May, 1902	....	......	....	......	....	......	....	......	....	......	61	61	....	......	39	39
Shortleaf Pine	100	Wellhouse, A.& L. Somerville	May, 1902	....	......	....	......	....	......	....	......	....	......	79	79	....	......	21	21
Shortleaf Pine	50	Allardyce, A.& L. Somerville	May, 1902	....	......	....	......	....	......	....	......	....	......	21	42	1	44	28	56
Shortleaf Pine	98	Barschall, A.& L. Somerville	May, 1902	....	......	....	......	....	......	74	75.5	....	......	23	99	....	......	1	1
Redheart Pine	100	Barschall, A.& L. Somerville	May, 1902	....	......	....	......	25	25	49	74	3	77	23	100	....	......	0	0

TABLE 9—CONTINUED—RECORD OF LIFE OF TIES IN EXPERIMENTAL TRACK ON THE BEAUMONT DIVISION OF THE GULF, COLORADO & SANTA FE RAILWAY IN TEXAS.

Kind of Wood	No. of Ties	Kind of Treatment	Year Inserted	Nov. 1903		June 1904		Nov. 1905		Dec. 1906		Feb. 1908		Nov. 1908		Sept. 1909		Ties Still in Track	
				No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Longleaf Pine	93	Untreated	April, 1902					85	91.4					1	92.5			7	7.5
Longleaf Pine	50	Zinc-Creo., Beaumont	April, 1902									19	38	1	40			30	60
Longleaf Pine	100	Burnett, A.& L. Somerville	April, 1902									27	27					73	73
Longleaf Pine	100	Wellhouse, A.& L. Somerville	April, 1902									3	5	52	55			45	45
Longleaf Pine	100	Barschall, A.& L. Somerville	April, 1902									95	95					5	5
Longleaf Pine	50	Allardyce, A.& L. Somerville	April, 1902									7	14					43	86
Longleaf Pine	100	Beaumont Oil, Somerville	April, 1902							70	70							30	30
Longleaf Pine	100	Beaumont Oil-Zinc Chloride.,	April, 1902															100	100
Longleaf Pine	100	Spirittine, A.& L.	April, 1902							8	8	72	80					20	20
LoblollyPine	100	Untreated	April, 1902			100	100											0	0
aLoblollyPine	49	Zinc-Creo., Beaumont	April, 1902															49	100
bLoblollyPine	99	Burnett, A.& L. Somerville	April, 1902															99	100
cLoblollyPine	99	Wellhouse, A.& L. Somerville	April, 1902															99	100
dLoblollyPine	49	Allardyce, A.& L. Somerville	April, 1902															49	100
LoblollyPine	99	Barschall, A.& L. Somerville	April, 1902					18	18.2	81	100							0	0
LoblollyPine	42	Beaumont Oil, Somerville	April, 1902					40	95.2									2	4.8
LoblollyPine	80	Beaumont Oil-Zinc Chloride.	April, 1902															80	100
LoblollyPine	100	Spirrittine A.& L. Somerville	April. 1902					80	80	18	98							2	2
Pines	84	Avenarius Carbolineum	April, 1905							1	1.2	76	91.7					7	8.3

Remarks: Longleaf and Loblolly soaked with Beaumont Oil absorbed 3 lbs. per cubic foot.
a—Original quantity, 50, one out for test.
b—Original quantity, 50, one out for test.
c—Original quantity, 100, one out for test.
d—Original quantity, 100, one out for test.
Zinc-Creosoted ties, Beaumont over steamed.
Mr. Chanute's Ties treated...... Chicago.
Ayer & Lord.................. Somerville.
International Creosote Co....... Beaumont.
Hasselman or Barschall by Ayer & Lord Co., Somerville.

Appendix B.

METAL AND COMPOSITE TIES.

The Proceedings of the Association for 1909 and 1910 contain descriptions or photographs of substantially all of the types of metal or composite ties in use by the various lines; together with reports from the roads having such ties in service; also information obtained by the Sub-Committees' inspections of many of those ties; therefore the work of the Sub-Committee on Metal and Composite Ties (W. F. H. Finke, Chairman; E. D. Jackson, F. R. Layng and H. S. Wilgus) for the current year has been confined almost entirely to the preparation of a progress report indicating what further developments have occurred in the use of metal or composite ties.

So far as the Sub-Committee could ascertain, no new type of practical design have been patented or installed; the roads which have installed metal or composite ties since the last Association report (Vol. 11) are indicated in this Sub-Committee report; the roads previously reported as using metal or composite ties were sent the following letter:

"* * * * This Committee was directed to prepare a progress report covering the metal and composite ties in use by the different lines; and, if consistent, we would thank you to advise us if there have been any further developments in connection with the use of such ties on your road since your last report to the Association; giving, especially, the details relating to renewals on account of failures from any cause.

"If any additional metal or composite ties have been installed, will you kindly state the number of each type placed, kind of fastenings, date and place of installation?"

A brief summary of the replies received follows:

Buffalo, Rochester & Pittsburg Railway:

(Previous reports indicate this company has about 3,000 Carnegie steel ties in service.)

Mr. E. F. Robinson, Chief Engineer, advises October 31, 1910:

"We have nothing further to report covering the use of steel ties on our line. The purchase of additional steel ties is not contemplated."

Bessemer & Lake Erie Railroad:

(For previous reports from this line regarding use of metal ties see Vol. 10, Part 1, p. 496; Vol. 11, Part 2, p. 876.)

Mr. F. R. Layng, Engineer of Track, writes November 19, 1910:

"In October of last year we reported to your Committee that up to that time we had purchased 342,058 steel ties, distributed as follows:

In 1904	1,200	Carnegie "I" Beam Ties
" 1905	24,979	
" 1906	79,750	
" 1907	146,129	
" 1908	500	
" 1908—Oct. first	89,500	

During the latter part of 1909, 26,668 more ties were purchased, making the total for that year 116,168, and during the year 1910 to November 1, 197,200 have been received, making a total of 565,929 ties received to date, or the equivalent to 188 miles of track. All of the ties received during the past year are of the same general dimensions, namely, 8 ft. 6 in. long, top flange 4½ in. wide, bottom flange 8 in. wide and the tie is 5½ in. deep. Average weight is about 180 lbs., exclusive of the fastenings.

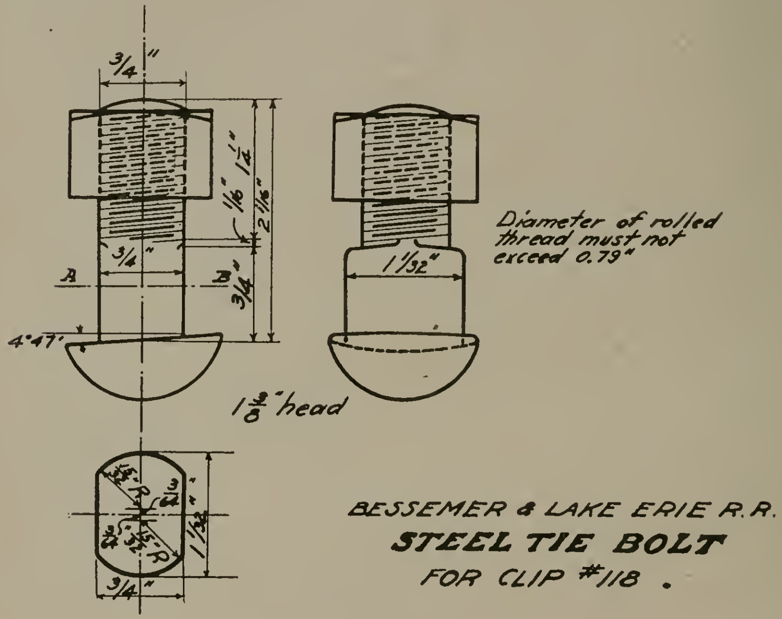


Fig. 1.

Since your Committee's last report, an improvement in the bolt and clip has been made, a plan of the new fastening being attached (see Figs. 1 and 2). This improvement, as will be seen from the plan, provides an oval hole in the clip instead of a round hole, and the oval neck on the bolt is extended up through the clip, thus making it impossible for clip to turn away from the rail. There is still another advantage in this arrangement in that it provides additional metal to take care of the shear on the bolt. All ties laid laid under the R. B. 100-lb. section are secured with these fastenings.

In connection with the first Carnegie Steel Ties installed, namely, the 1,200 at Claytonia, Pa., which were put in during the latter part of 1904, and which your Committee examined in detail last year, we would advise that there has been no change in these ties as far as we can see, since your inspection. The track is in good line and surface. No special work has been necessary on these ties during the year, and, as far as can be seen at the present time, none will be necessary in the near future. This track has been maintained during the year by the regular section gang, consisting of a foreman and an average of five men. The section is four miles long and of double track, one, namely, the southward, being laid with steel ties in the face. About 25 per cent. of the northward track is laid with steel ties. During the summer an average of slightly over one million tons (exclusive of weight of cars and engines) per month, and from January 1 to October 1, over six million tons (exclusive of weight of cars and engines) have been hauled over those ties.

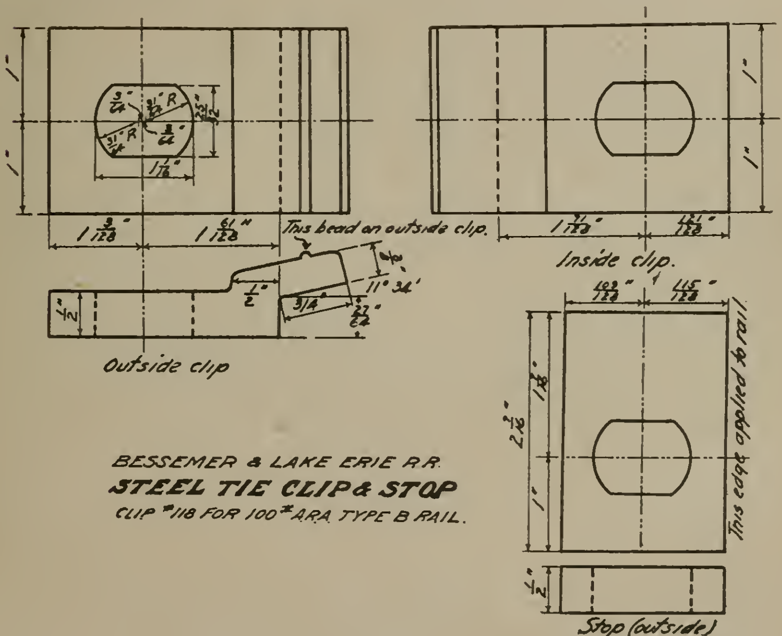
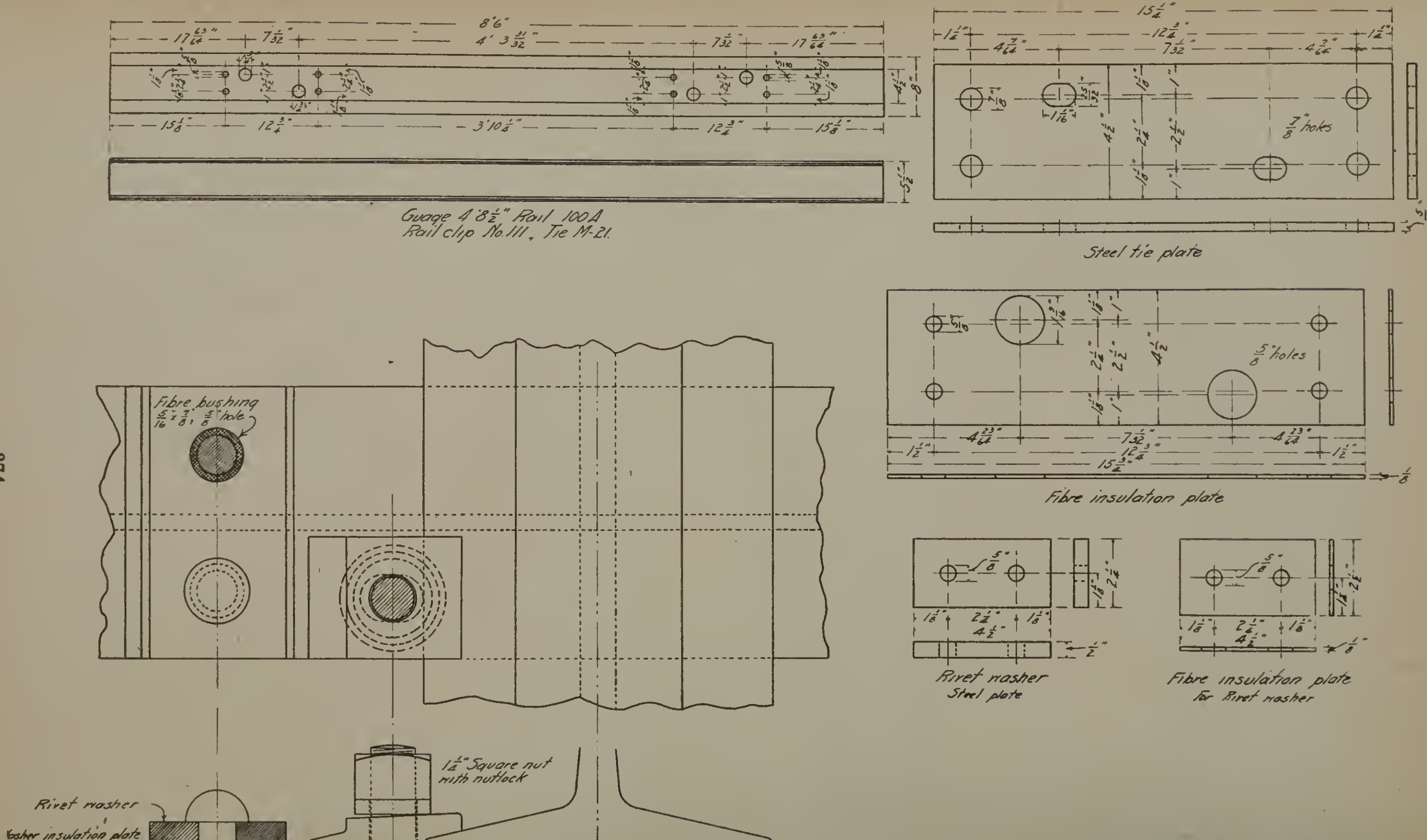


FIG. 2.

The 1,000 insulated ties installed June, 1906, near Conneaut, Ohio, are still in the track and have given no trouble whatever. We have had no trouble with the insulation, and for the benefit of your Committee we have taken one of these ties out of the track and cut out the fiber, which is sent you under separate cover for your inspection. You will see that this fiber is in excellent condition, and, as far as we can see, will last for a number of years.

The past year's experience has developed nothing in regard to the steel tie that is not favorable to its continued use; in fact, it has only strengthened our opinion that we are using a practical and an economical substitute for the wood tie.



BESSEMER & LAKE ERIE R R
INSULATED STEEL TIE

The Sub-Committee examined the fiber mentioned in the foregoing report from Mr. Layng, and found it in very good condition, and apparently good for several years' further service. Fig. 3 shows this insulation as applied to the steel ties with bolt and clip fastening. (The insulation as applied to the wedge fastening is shown in Vol. 10, Part 1, p. 504.)

The accompanying photographs, Figs. 4, 5 and 6, show some of the steel tie track on the Bessemer & Lake Erie Railroad.

FIG. 4.—BESSEMER & LAKE ERIE RAILROAD, FINISHED TRACK NEAR FREDONIA, PA.

(Photo. taken November, 1910, two months after track was put up.)

New York Central & Hudson River Railroad:

(In 1909 this road advised that one mile of Carnegie steel ties was laid in its main track near Castleton, N. Y., during 1904; early in 1907 this track was turned into a siding or freight track.)

Under date of November 9, 1910, Mr. George W. Kittredge, Chief Engineer, advises:

"We have no such ties in use on the New York Central other than a few Buhrer steel ties, controlled by the Carnegie Steel Company. These ties are all in passing sidings and there have been no further developments in connection with the use of such ties since our last report to the Association."

Pittsburgh & Lake Erie Railroad:

(For earlier reports regarding use of steel ties on this line see Vol. 10, Part 1, p. 503; Vol. 11, Part 2, p. 883.)

Fig. 5.—Bessemer & Lake Erie Railroad, Track Near Meadville Junction, Pa.

Six degree curve, seven-in. elevation, gravel ballast. Speed of train about sixty miles per hour.

Fig. 6.—Bessemer & Lake Erie Railroad.

Derailment of loaded steel car of coal, near Shermansville, Pa., May, 1910; cause, broken axle; one truck derailed. Photo. taken October, 1910.

Mr. J. A. Atwood, Chief Engineer, encloses following report from Mr. Edwin F. Wendt, Assistant Engineer, dated November 16:

"Carnegie Steel Ties with Wedge Fastenings.—Six ties of this design were placed in northbound main track at Pittsburgh Terminal Station in May, 1908. They have been under test two and one-half years.

"After a few months service the wedges became worn and it has been found impossible to keep those wedges tight. The ties are still in the track and the design is defective in the fastenings.

"The insulations, with respect to automotic signals, are in good condition and have never been removed during the time of the test.

"The effect of this design of cross-tie on line and surface cannot be stated because of the limited number of ties in use.

FIG. 7. ATWOOD CONCRETE-STEEL TIES.

"Carnegie Steel Ties with Bolt and Clip Fastenings.—As reported in the Proceedings of 1909-1910, 3,000 steel ties of this design were laid in August, 1907, in No. 3 main track, used by northbound freight trains, in McKees Rocks (Pa.) Yard, located about four miles north of Pittsburgh.

"These ties have now been in the track three and one-half years; 90-lb. rail is used with those ties and the track is ballasted with 12 inches of limestone. The drainage is good. A four-track railroad is operated in this district. The average speed of freight trains at this point during the past year has increased from 20 to 30 miles per hour, on account of the establishment of through runs.

"Automatic electric signals are in use in this district and the fiber insulations of the ties, at the end of the three and one-half years above mentioned, are gradually deteriorating, and a number of the fiber plates, especially under the joints, have become worn a sufficient amount to cause the bolts and clips in the fastenings to become loose. As a result the rails are creeping and some of the ties are being slewed. During the first year of the experiment this condition was not noticed, and in the early life of this device there was no creeping and no slewing. The design of fastening is responsible for the change in condition.

"It was stated in the report of 1910 that the fiber insulations were approaching the end of their life. During the past year, however, no renewals of fiber have been made and no signal trouble has been experienced. It is natural, however, to expect that fiber which has been in use for 42 months should be near the end of its life.

"The section of track laid with these steel ties is 4,400 ft. long; the next succeeding section of the same track is laid with white oak cross-ties. The conditions as to rail, drainage and ballast are the same. A comparison of these two sections of track is being made and a record of maintenance of expense is being kept.

"During the first year neither section of track was resurfaced. During the second year both sections of track were resurfaced once. During the third year (1910) the steel tie section was resurfaced three times, while the wooden tie section was resurfaced twice. A statement of comparative costs of labor incident to maintenance will be ready for the convention of 1911."

"Atwood Concrete Steel Ties.—These ties were designed by J. A. Atwood, Chief Engineer Pittsburgh & Lake Erie Railroad Company.

"Five ties of this design were placed in No. 4 main track, used by northbound passenger trains, at McKees Rocks, Pa., in October, 1908.

"At the present time the ties and fastenings are in perfect condition The track is in good line and surface and there has been no signal trouble."

Union Railroad (of Pittsburgh, Pa.):

(For previous report see Vol. 11, Part 2, p. 884.) No reply received.

The Committee was informed too late to make an inspection that this railroad has installed about 7,000 Carnegie ties, fastened with a type of fastening known as the Hill fastening. These ties were installed at the Duquesne plant of the Carnegie Steel Company on curves as sharp as 21 degrees. All of these ties were installed under yard tracks. The fastening consists of a metal box filled with wood, into which a common track spike is driven. A photograph and plan of this fastening is shown herewith.

Pennsylvania Railroad:

Mr. L. R. Zollinger, Engineer Maintenance of Way, states October 31, 1910: "We are not at the present time conducting any experiments with metal or composite cross-ties, and are therefore unable to give you any data on the subject."

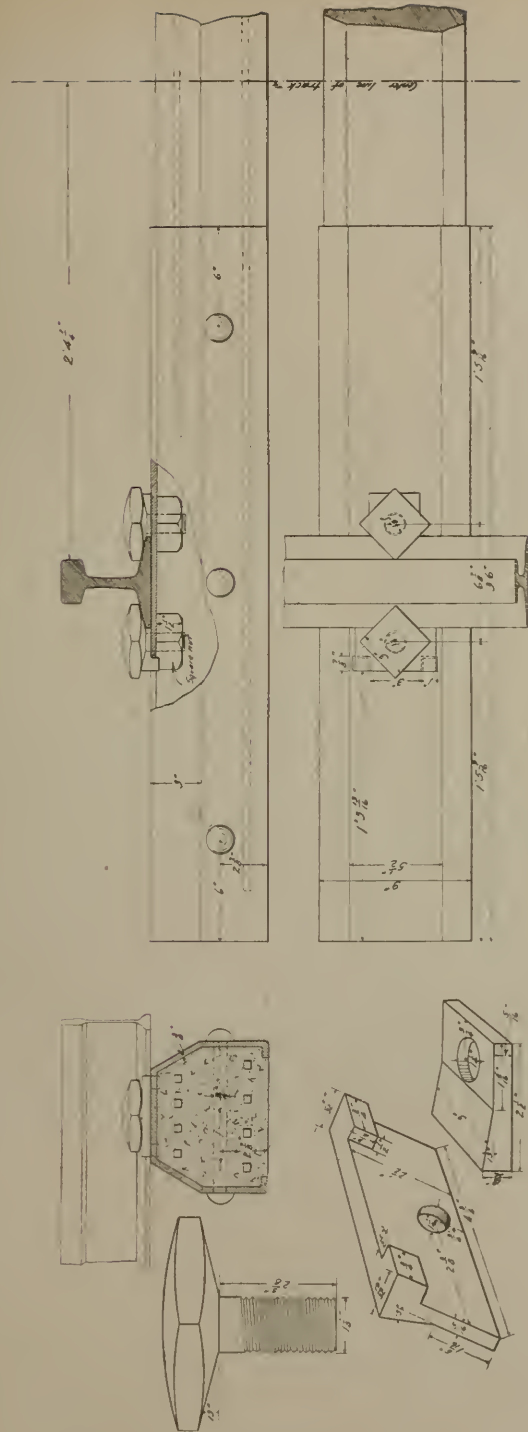


FIG. 8.

Pennsylvania Lines West of Pittsburg:

(For previous reports see Vol. 10, Part 1, p. 505; Vol. 11, part 2, p. 885).

Southwest System:

Mr. W. C. Cushing, Chief Engineer Maintenance of Way, advises November 11, 1910, that no metal ties have been used, and gives following information relative to the Chenoweth Reinforced Tie and Bruknor Reinforced Concrete Tie, those being the only composite ties they have on trial:

FIG. 9. HILL FASTENING, UNION RAILROAD.

"Chenoweth.—101 placed in No. 5 track, Scully Yard, October, November and December, 1906. Cost $1.50. Ties 8 ft. long, 7 in. wide on top, 8¼ in. wide on bottom, 6 in. thick, reinforced with a coil of No. 16 gage wire mesh, the coils being about ½ in. apart, and six ½-in. rods, three near top surface and three near bottom surface of tie. The rail rests

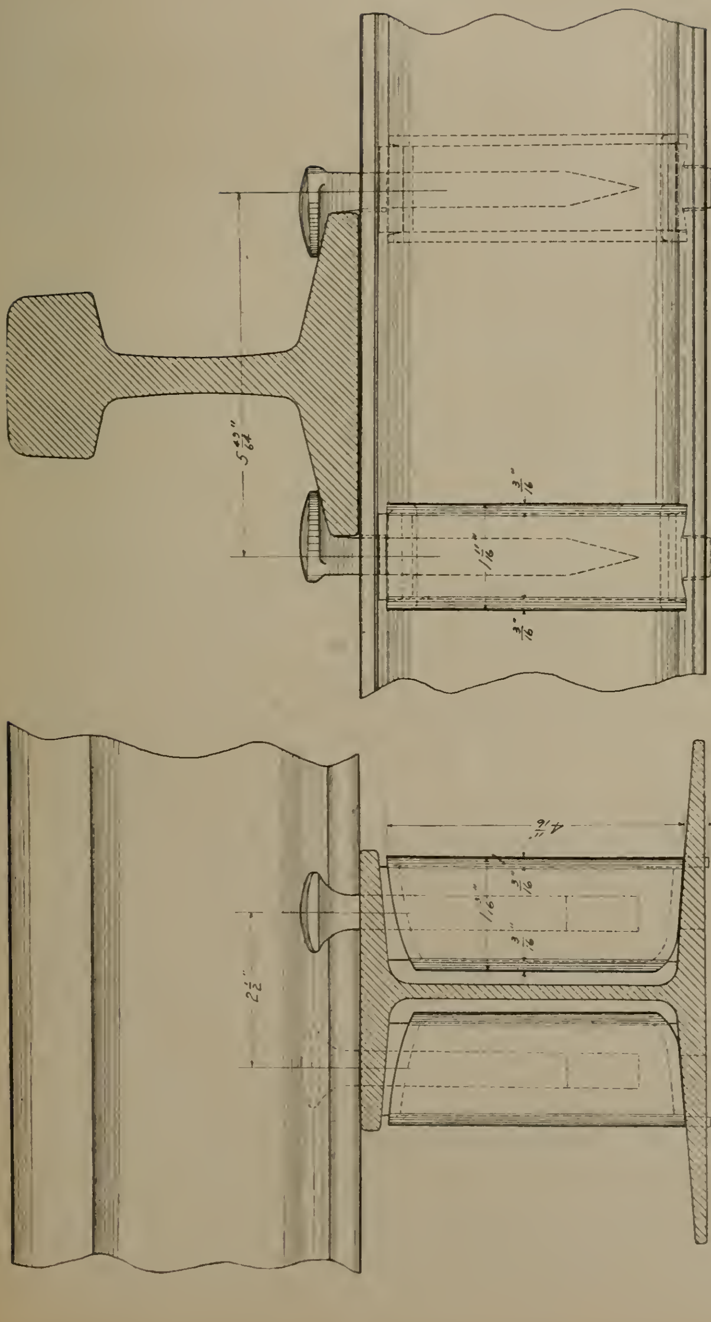


FIG. 10. · 100 RB RAIL. M-21 TIE & HILL FASTENING.

on a wooden block ⅞-in. by 7 in. by 12 in., and is secured by screw spikes and clips. The screw passes through a helical lining 2⅜ in. long, imbedded in white metal in hole through tie.

"Curvature, two degrees; ballast, cinder; tie spacing 18 to 33 ft. rail. Rail, 85-lb. A. S. C. E. section. Traffic, heavy; speed slow; average, five miles per hour. Prior to July 6, 1908, four were removed to provide space for two insulated joints; two of these were in good condition, two crumbled under rail. July 6, 1908, to April 28, 1909, ten intermediate ties, all badly crushed under rail, were removed.

"When inspected May 1, 1909, of 87 in track 22 were crushed under one or both ends, 6 were cracked under one rail, 18 cracked in middle, and 41 in apparently good condition. On September 22, 1909, 16 were removed on account of failure. On December 2, 1909, 13 were removed on account of failure. Between December 2, 1909, and May 11, 1910, one was removed on account of failure. When inspected May 11, 1910, of 57 in track, 16 were crumbled beneath rail and 4 were cracked.

"On November 1, 1910, 24 were removed on account of failure. At present date, just four years after installation, 67, or two-thirds of these ties, have failed and been removed from track. Had they been placed in a high-speed main line they would have been taken out earlier than they were. We anticipate that all will be removed before another year."

"Brukner.—Eighteen placed in No. 5 track, Scully Yard, December 2, 1909. Ties 8 ft. 2 in. long, 8 in. wide on top and 9½ in. on bottom under rails, 2 in. wide on top, 8 in. at bottom, except under rail, 5 in. thick, reinforced with ten longitudinal 5/32-in. iron rods near top surface and sixteen longitudinal 5/32-in. iron rods near bottom surface; these rods are fastened together with 5-128-in. wire binders.

"Each tie has four wooden plugs 2 in. square on top and 3 in. square on bottom, imbedded in it to receive fastenings.

"The rail rests on a steel plate ½-in. by 7 in. by 10½ in. with a wooden plate of same size underneath, and is fastened to tie with steel clips and French screw spikes.

"Curvature, etc., same as for Chenoweth ties, some of which were taken out and replaced by Brukner ties.

"When inspected May 11, 1910, two joint ties in south (low) rail were broken and joint deflected ¼-in. Two joint ties in north (high) rail were cracked, but joint not deflected. The breaks noted above are directly under rail and ties have not crumbled as yet. Small cracks were found in two or three intermediate ties where section of ties change just inside of rails.

On November 1, 1910, ten of the above eighteen ties were removed from track on account of failure, and on November 9, one tie removed. The seven remaining ties are in fair condition. The patentee, Mr. Brukner, was in this country last summer and inspected the above ties. He reported them designed for European wheel loads and too light for our traffic. He has since furnished twenty additional ties, larger and more heavily reinforced, which he thinks will carry our traffic. These will be installed in track as soon as fastenings are received."

Northwest System:

Mr. Robert Trimble, Chief Engineer Maintenance of Way, writes November 17, 1910:

"I beg to advise that nothing new has developed, except that on June 15, 1910, we placed in our main tracks twelve steel ties, made by Messrs. J. T. Rohm and J. W. Gumbert. They were placed in No. 3 track, west of Chestnut street, Sewickley, Pa., but they have not been in the track a sufficient length of time to draw any conclusions as to their value. Attached please find blueprint showing their construction."

Pittsburgh, Shawmut & Northern Railroad:

(Previous advices state this company installed about 795 of Carnegie ties during 1907; see Vol. 10, Part 2, p. 885.)

Under date of November 5, Mr. H. S. Wilgus, Engineer Maintenance of Way, writes:

"In reply to your circular letter asking for further experience in the use of steel ties, would state that since the last report the ties have continued to give uniform satisfaction. I have had the two ties which were weighed and mentioned in the last report weighed again, about a year interval, and find that there has been no loss of weight. The following is a letter received from Roadmaster John Benson, which is self-explanatory:

" 'Referring to attached in regard to steel ties, I have not had much experience with steel ties, but so far as I have seen of the ties we have in use they have given very good satisfaction. Curve south of Byrnedale water tank was layed with steel ties, excepting the joint ties, about three years ago, and this curve has received but a very little work since that time.' "

Cleveland, Cincinnati, Chicago & St. Louis Railway:

(This company has about one mile of Carnegie steel ties in its westbound track between Newpoint and Greensburg; see Vol. 11, Part 2, p. 887.)

Mr. C. A. Paquette, Assistant Chief Engineer, writes under date of October 31, 1910:

"There has not been, since last report, any change in the use of metal ties on this road, nor have we applied any additional number."

Mexican Railway:

(For previous report from this company see Vol. 11, Part 2, pp. 887-88-89.)

On November 10, 1910, Mr. W. T. Ingram, Resident Engineer, states:

"We have installed 43,000 steel ties this year up to date, and probably the total for the year will be 50,000. All these ties are of our new design (plan of which you already have), and the rails are held by means of clips and U bolts. Most of these ties have been used when laying new 85-lb. rail; the remainder for respacing. We have had a good many failures of steel ties of an old and obsolete design, but no record has been kept of these."

Boston & Maine Railroad:

(Report in Vol. 11, Part 2, p. 890, indicates this company installed in its Boston Yard one set of No. 6 Carnegie steel switch ties.)

No reply received.

Duluth & Iron Range Railroad Company:

(This line installed 2,000 Carnegie steel ties during 1905; see Vol. 11, Part 2, p. 890.)

On October 31, Mr. W. A. Clark, Chief Engineer, wrote:

"* * * There have been no further developments in connection with the use of steel ties since my last report. No ties have needed renewal or any special attention, and we have not installed any additional ones, either of that type or any other."

Northern Pacific Railway:

(A previous report states that this company installed about 60 Carnegie ties during 1906, at five different water tanks, to replace wooden ties which were frequently burned at these points.)

On November 5, 1910, Mr. W. C. Smith, Chief Engineer of Maintenance of Way, advised:

"There have been no further developments in connection with the use of metal ties on this road, except that we have found it advisable to remove one or two sets of these ties where they came within the limits of the automatic block signals which are being installed along this system. We preferred to remove the ties rather than to insulate them."

Lake Terminal Railway:

(For previous report see Vol. 11, Part 2, p. 890.)

Lehigh Valley:

This line is using few steel ties encased in concrete in ashpits.

Delaware & Hudson Company:

Using few Carnegie steel ties in cinder pits.

Lake Champlain & Moriah Railroad:

(Previous reports state this line had 48 Carnegie steel ties in service; see Vol. 11, Part 2, p. 891.)

No reply received.

Lake Shore & Michigan Southern:

(Have in use some Buhrer concrete ties, also some combined wood and steel ties.)

No reply received.

Chicago & Alton Railroad:

(This line placed 63 "Kimball" ties in its southbound track near Lockport, Ill., during October, 1905; see Vol. 10, Part 1, p. 515; Vol. 11, Part 2, p. 893.)

Under date of October 31, 1910, Mr. W. D. Taylor, Chief Engineer, states:

"Since our last report to the Committee there have been no changes as regards ties in track on this company's lines. We have put in no metal or composite ties."

Galveston, Harrisburg & San Antonio Railway:

(This line installed some Percival concrete ties during October, 1906; see Vol. 11, Part 2, p. 894.)

Mr. A. V. Kellogg, Engineer Maintenance of Way, advises November 1, 1910, that he will prepare report on those ties on January 1, 1911.

Baltimore & Ohio Railroad Company:

(One mile of Carnegie steel ties laid in old main line east of Marriottsville, Md., during November, 1906; see Vol. 10, Part 1, pp. 504 and 529.)

Under date of November 17, Mr. E. Stimson, Chief Engineer Maintenance of Way, wires:

"Have no further report to make covering steel ties. We did not install any new metal ties during last year."

On November 21, 1910, the Sub-Committee on Metal and Composite Ties inspected the above ties. During the past season the track has been reballasted with stone, surfaced and lined, and the Sub-Committee found general conditions on the steel tie track to be about the same as on the adjoining wooden tie track.

Lake Terminal Railway:

Mr. F. W. Waterman, Engineer, writes December 3, 1910:

"We have about 62 miles of standard gage track, 17 per cent. of which is equipped with steel ties, and we are replacing the wooden ties with Carnegie steel ties, section M-21, as fast as the wooden ties give out. We expect to replace about 10 per cent. of the wooden ties in the year 1911. We have had some of these ties in use four years and find them very satisfactory.

"We have made a slight modification in the clips, due to the fact that where they were placed on track rails at curves of short radius, the tendency was to work loose. We use a clip of our own design, which extends to the web of the rail, preventing the clip from turning off in case of loose bolt. After the clip is bolted tight it is prick punched, to prevent, as far as possible, the clips working loose.

"We also use a special clip over the top of the splice bar flange.

"We have had excellent results at switches, the long switch ties supporting four (4) rails, which make a complete bond at the heel of the frog, thus holding the track in better alinement. This method provides better facilities for tamping than where staggered wooden ties of standard length are used.

"In addition to our standard gage track work we have in a number of cases used steel ties for extra heavy loads; in fact, one of our ore bridges, which has a heavy concentrated load, caused trouble on account of our inability to keep up the tracks. We used standard steel ties bedded in solid concrete, and these have been in use for two years with absolutely no trouble.

"In general, we beg to report that if we had the selection (after the experience we have had with these ties) between wooden and steel ties, we would, without any reference whatever to the additional cost, select the steel ties."

Erie Railroad:

Mr. W. J. Harahan, Vice-President, advises as follows:

"On the Meadville Division we have, at Jamestown, 289 steel ties of the Carnegie type, which were put in in September, 1909. They have not been in the track long enough to say very much about them, except that we have had no trouble in keeping the track in surface. We also received one set of No. 10 switch ties, which were placed at Cleveland, May, 1909, and one set of switch ties, which were placed in the Bergen Yard, April, 1909."

The Sub-Committee wrote these lines, replies being received from but two, as follows:

Michigan Central Railroad:

November 19, Mr. George H. Webb, Chief Engineer, advised:

"We have had practically no experience with metal ties on this road, and I might say the same of composite ties. The only thing in the way of composite ties that we have tried is a few reinforced concrete ties, which were made by a party at Jackson, Mich."

Long Island Railroad:

Mr. J. B. Austin, Jr., Engineer Maintenance of Way, writes December 2, 1910:

"We have installed metal ties at two interlocking plants on this road to provide spaces under the track for our pipe leadouts. From a track standpoint and for the purpose of giving sufficient space for the pipe runs, the ties have been entirely satisfactory. The old trouble of properly insulating them, though, is cropping up. We made a test of the installation a few days ago and find that the fiber bushings where the rail insulation is riveted to the tie are beginning to leak. The ties we are using are of the Carnegie Steel Company's type."

TRACTION LINES.

Twin City Lines (Minneapolis, Minn.):

(Previous report shows this company has about 1,000 Carnegie ties in street use.)

Under date of November 10, Mr. George L. Wilson, Engineer Maintenance of Way, writes:

"We have made no further use of ties of this kind; therefore, there is nothing to add to previous reports."

Utica & Mohawk Valley Railway:

(Previous report states this line has about 4,700 Carnegie ties in use; see Vol. 11, Part 2, p. 897.)

November 1, 1910, Mr. M. J. French, Engineer Maintenance of Way, reports:

"We have used this year 1,433 Carnegie M-25 steel ties, under 80-lb. A. S. C. E. tee-rail, with concrete construction and brick pavement, in the village of New Hartford, and we have used 2,414 steel ties of the same type, under 60-lb. tee-rail, with concrete bitulithic pavement, in the village of Whitesboro. We have also used four sets of switch ties, 56 ties in all, of the same section, under 80-lb. A. S. C. E. tee-rail, with concrete construction and bitulithic pavement. We have had no renewals on account of failures or for any other cause and are more convinced than ever that the steel ties with concrete and tee-rails gives us the best type of track construction for paved streets. We have used with the ties placed this year the Carnegie No. 23 type of rail fastening and have found it very satisfactory."

Joliet & Southern Traction Company:

(This line has 300 steel ties in use in paved streets.)

Mr. L. D. Fisher, Superintendent, advises on November 2, 1910:

"The metal ties used by this company are all laid in concrete covered with brick pavement and have now been down three years. The track is in perfect condition and we have had no occasion to open up the ties since they were laid."

Boston Elevated Railway Company:

(For prior report see Vol. 11, Part 2, p. 898.)

Mr. A. L. Plimpton, November 5, 1910, states his company has installed the following steel ties:

1905— 760 Lorain Steel Co. ties. (Their catalogue No. 13, p. 160.)
1908— 94 Carnegie ties. (Section M-14-½-lb. per ft., 7 ft. long.)
1909—1,570 Carnegie ties. (Section M-14-½-lb. per ft., 7 ft. long.)
1910—2,235 Carnegie ties. (Section M-14-½-lb. per ft., 7 ft. long.)

As an experiment they have made about 600 reinforced concrete ties, none of which, however, have as yet been put in the ground.

Syracuse Rapid Transit Company:

(A previous report states this company has several thousand steel ties in use in paved streets.)

No reply received.

Virginia Railway & Power Co. (Richmond, Va.):

(In a prior report this company stated it had several thousand Pennsylvania and Lorain Steel Company steel ties in use; also several hundred Carnegie steel ties; see Vol. 11, Part 2, p. 898.)

On October 31, 1910, Mr. Calvin Whiteley, Jr., Chief Engineer of Railways, wrote:

"We have adopted the metal ties for all city work in concrete. We have been using the ties made by the Lorain and the Pennsylvania Steel Companies, but have finally adopted the Carnegie tie M-25. My objection to using this tie heretofore was on account of the method of attaching the rail to the tie. I have solved this, however, to my own satisfaction by using the Carnegie tie with the Lorain brace. The 150 metal ties recently put in our car shed on Robinson street were of the Carnegie type, and the 400 on Main street of the Lorain type."

Chicago City Railway Company:

(In 1909 this company advised it had installed Carnegie steel ties in Cottage Grove avenue, between Fortieth and Seventy-first streets.)

No reply received.

Denver City Tramway Company:

(This company installed 2,500 Carnegie ties during May, 1908, in connection with concrete paving; see Vol. 11, Part 2, p. 898.)

Mr. John Evans, Chief Engineer, states November 3, 1910:

"There have been no further installations of such ties, or repairs, or other data, on those already installed by us. It might be well to note, however, that we have had more trouble with the maintenance of street paving where the steel ties are than where wooden ties have been used, presumably due to increased rigidity and vibration."

Oklahoma Railway Company (Oklahoma City):

(In 1909 this company advised it had about four miles of 6-in. base Carnegie steel ties in use in concrete street railway; see Vol. 11, Part 2, p. 899.)

Mr. W. A. Hallor, General Manager, writes November 8, 1910:

"We now have about ten miles of steel tie, concreted paved construction, in city streets. We are using the Carnegie steel tie, section M-25, 6 in. top, and Section M-21, 8 in. top, for joint ties; all ties 6 ft. 6 in. long fitted with No. 23 new style clips and bolts, the present track standard being 100-lb. A. S. C. E. rail, with Carnegie ties spaced three-ft. centers, and with twisted bar reinforcement in the concrete bottom underneath the ties. We recently made an examination of some of the construction installed one year and eight months ago, which is still in a perfect state."

Brooklyn Heights Railroad Company:

(Previous reports state this company is using Carnegie steel ties to a limited extent.)

November 2, 1910, Mr. C. L. Cabbs, Engineer Maintenance of Way, writes:

"There have been no further developments in connection with the use of metal and composite ties since our last report. We have discontinued, for the present, the use of the metal tie, and have had no occasion to make renewals of those already installed."

San Antonio Traction Company (*San Antonio, Tex.*):

(A prior report states this company laid 500 ft. of double track with Carnegie steel ties in 1908, spaced five ft., ties being laid in concrete.)

Mr. L. B. Tuttle, Vice-President and General Manager, writes on November 3, 1910:

"So far we have had no failure in the metal ties that we have used."

Cleveland Railway Company:

This company has laid one mile of track with steel ties manufactured by the International Steel Tie Company of Altoona, Pa. These ties are 6-in. "I" beams arranged in pairs, with concrete blocks and steel plates under the rails between each pair of the ties. The plates are slotted to receive three metal clips on either side of the rail. Wedges are driven back of the clips to hold them in place. The joined pairs of ties are 30 in. apart, while the spacing between pairs is 19 in. The plates are 12 in. wide by 30 in. long and $\frac{5}{16}$ in. thick. The ties, plates, clips and wedges weigh 188 pounds per pair. The track is laid with 80-lb. A. S. C. E. rail, ballasted with 12 to 16 in. of screened rock.

The Committee is informed that this company are using a number of Carnegie steel ties in concrete, but we have no further information on what they have done with this type of tie.

Appendix C.

THE USE OF CYPRESS AS TIE TIMBER.

The increasing use of cypress as a tie timber has led the Committee to make some investigations concerning same, and accordingly a post-card inquiry was sent out to proper officers of all the roads operating in the South Atlantic and Gulf states, where cypress ties are most generally used. The following questions were asked:

Number of Cypress ties in track; Dimensions; Kind of Cypress; Red, White, Yellow; Pecky, Clear; Average life; Remarks.

Replies were received from a great many roads giving the information wanted. Several roads replied that they had many cypress ties in track but had no accurate record, and consequently gave no figures, while a number made no reply.

The information obtained is tabulated and published in the appended table.

There are no publications of the Forest Service covering Cypress Timber, but it is said a bulletin is in course of preparation.

DATA RELATING TO CYPRESS TIES.

Name of Road	Official Reporting	No. of Ties in Track	Dimensions	Kind of Cypress	Clear or Pecky	Average Life in Track	Remarks
Central of Georgia	C. A. Lawrence, Chief Engr.	1,334,739	7x8x9	Red and black		No accurate date; 10 to 12 years when protected with tie plate.	The number given is the number of red and black cypress ties that have been put in track since 1900, averaging 133,474 per year.
Charlotte & Western Carolina R. R.	A. H. Porter, Engr. R'dway.	440,000	7x9x8½	Red and black		12 to 14 years	White and yellow cypress not used in this section. Will not last more than 2 or 3 years. Tie plates required where traffic is heavy and on curves.
Chicago, Rock Island & Pacific	J. B. Berry, Chief Engr.	None					Think of trying some pecky cypress in Louisiana.
Cleveland, Cincinnati, Chicago & St. Louis R. R.	C. S. Millard, Engr. Track & Roadway	2,200					1,000 on Cairo Division, 1,200 on Vincennes Division in Illinois, been in about 7 years, are in fair condition.
Florida Central Ry	J. H. Davidson, Gen. Supt.	None					We will use red and black cypress after this year.
Florida Railway Georgia & Florida	W. A. Swallow, Ch. Engr. Superintendent,	10,000 20,000		Red Red and white	Clear		O. K. with tie plates. Practically all ties new within last 2 years.
Georgia Coast & Piedmont	T. S. Williams, Roadmaster	50,000	6x8 to 7x10	Red and white All classes			
Georgia Railroad	W. M. Robinson, Roadmaster	30,000	7x8x9	Red, black and yellow	Pecky		Have been in use about 4 years. As cross-tie timber white cypress is of little value.
Illinois Central	A. S. Baldwin, Chief Engr.	2,000,000	6x8x8 7x9x9	Red, black and yellow	Some pecky mostly clear		We find the average of white or yellow cypress ties, if ¾ sap, 2 to 3 years; if all heart, 8 to 12 years; red, 12 to 15 years.

DATA RELATING TO CYPRESS TIES—Continued.

Name of Road	Official Reporting	No. of Ties in Track	Dimensions	Kind of Cypress	Clear or Pecky	Average Life in Track	Remarks
International & Great Northern....	O. H. Crittenden, Chief Engr.	200,000	6x8x8	Red and yellow	20% pecky 80% clear	12 years	More than ¾ wear out, life of other ¼ about 12 years.
Louisiana Railway & Navigation Co.	C. R. Mee, Roadmaster	95% of 333 miles	6x8x8 7x9x9	Red		Red, 11 years; yellow and white heart, 8 years.	Cypress is the tie for this climate.
Louisville & Nashville..............	W. H. Courtenay, Chief Engr.	1,397,915	7x9x9	Red, white and yellow			All laid on divisions south of Montgomery.
Missouri Pacific Railway...........	M. L. Byers, Chief Engr. M. of W.	100,000	6x8x8	Red and white	Both		Would not recommend using cypress ties unless I could get all heart.
Mobile & Ohio.......................	B. A. Wood, Chief Engr. of Maint.	10,000	7x9x8.5	Red and white	Both		Red and yellow cypress ties are the best, from 2 to 4 years longer than white oak under similar conditions.
Norfolk & Western.................	C. S. Churchill, Chief Engr.						Up to 1890 this road used large numbers of cypress ties, secured along its line in eastern part of Virginia. We found their life to be from 12 to 14 years. The demand for cypress for shingles, etc., became so great, no longer put on market for cross-ties. We ceased buying cypress for ties in early nineties. Last few years have been using red cypress ties in track in tunnels.
St. Louis & San Francisco.....	M. C. Byers, Chief Engr. Operation	175,000	6x7x8 6x8x8 6x8x9 7x10x8			10 to 15 years for red and yellow	50,000 red cypress treated ties in Oklahoma, 115,000 red cypress untreated ties S. E. Mo. and N. E. Arkansas. Will outlast oak. White cypress not good. Pecky cypress will last long time but will not hold spikes.

DATA RELATING TO CYPRESS TIES—Continued.

Name of Road	Official Reporting	No. of Ties in Track	Dimensions	Kind of Cypress	Clear or Pecky	Average Life in Track	Remarks
St. Louis, Brownsville & Mexico.....	E. C. Burgess, Engr. M. of W.	207,775		Red, white and yellow	Both		
Seaboard Air Line	J. C. Nelson, Engr. Maintenance of Way	2,000,000	7x9x9	Red and black	Both		If you are gathering data to get up specifications, I would suggest that you omit the names of different kinds of cypress and simply specify heart cypress. My experience has been that the names are simply local, and that what is known as yellow and red, etc., in one state, may be entirely different in another, but the heart of any cypress in any state, no matter what its local name may be, is all right. On the other hand, cypress known as red, black or yellow is worthless, unless it has heart. We get cypress in North Carolina, South Carolina, Georgia, Florida, Alabama and some little in Eastern Virginia. Timbermen in some of these sections will tell you that yellow cypress is all right, and another will say that it is worthless, and after some years' experimenting and groping in the dark, I found that the name cuts no figure, and while along the line of our road we use the names red and black, it really means nothing and we are very careful to specify the heart dimensions.
Sunset Lines, Atlantic System........	A. V. Kellogg, Engr. M. of W.	5,705,567	6x8x8 7x8x8 7x9x8 7x9x9 8x10x10	White	Clear		

DATA RELATING TO CYPRESS TIES—Continued.

Name of Road	Official Reporting	No. of Ties in Track	Dimensions	Kind of Cypress	Clear or Pecky	Average Life in Track	Remarks
Tampa & Jacksonville	F. C. Parrigin, Engineer	7,000	7x9x8.5	White	Clear		These ties have been put in, in last 24 months. Indications are they will last about 4 years.
Texas & Pacific Ry	B. S. Wathen, Chief Engr.	2,633,664	7x9x9 6x8x8	Yellow, red and black	Clear		We have not had any cross-ties of this class in use longer than 7 years; believe 10 years about the average life.
Vicksburg, Shreveport & Pacific New Orleans & Northeastern	E. Ford, Asst. to Prest.	175 miles 46,000	7x9x9 7x9x9	Red and yellow Red and yellow	Both	12 years	V. S. & P. Delta Point to Shreveport; 175 miles laid with cypress ties, 2,816 to the mile, only receive red or yellow cypress. Do not object to pecky ties if they are not so pecky as to prevent holding spikes; yellow cypress ties do not last as long as red cypress ties but last considerably longer than pine or oak ties. V. S. & P. has no curvature exceeding one degree; have but little trouble with cypress ties on curves. The cross-ties on the N. O. & N. E. would get too soft and have to be taken out from mechanical wear instead of from decay. Cypress ties on N. O. & N. E. are of poor quality and will not last as long as ordinary pine ties.

Total No. of Ties in Track, 17,780,075.

Appendix D.

ABRASION OF CROSS-TIES BY TRACK RAILS.

As opportunity has offered, the Sub-Committee has examined ties removed from track by sectionmen in the regular work of renewals, and measurements to determine depth of cut were made by means of a straight edge and a wedge-shaped graduated gage. It was found that where ties are not protected by tie-plates the cutting or abrasion of the ties by the rails and the outward tilting of the rails is marked on tangents as well as curves, and adzing of the ties at intervals is necessary on both curves and tangents to maintain the rails in position perpendicular to the plane of the tie. The measurements taken show the maximum cutting of the ties, as all ties examined had been removed from track. From observations and from information obtained, the Sub-Committee is of the opinion that flanged tie-plates of suitable width and thickness and properly applied on tangents as well as on curved track, will lengthen the life of cross-ties from one to two and in some cases three years, and in the meantime the track will have been maintained in better gage, line and surface, and at less cost, than the same track could have been without tie-plates.

The Sub-Committee gives below some notes made during the investigation.

Information as to abrasion of ties by 85-lb. A.S.C.E. rails without tie-plates.

Single track, heavy traffic, white oak ties, tangent. Ties taken out in making renewals. Age 7 to 8 years.

Outside edge of base of rail.	Inside edge of base of rail.
½ in.	¼ in.
1 in.	½ in.
1 in.	¾ in.
¼ in.	⅛ in.
½ in.	¼ in.
½ in.	¼ in.

Tangent eastbound track, heavy traffic, white oak ties. Age about eight years. Slag ballast.

Outside edge of base of rail.	Inside edge of base of rail.
7/16 in.	6-16 in.
9/16 in.	5/16 in.
5/16 in.	2-16 in.
6-16 in.	2-16 in.
1 in.	8-16 in.
1 in.	12-16 in.
12-16 in.	8-16 in.

Curve westbound track, yard, slow movement empty cars—tie-plates under outside rail at detector bar interlocked track. Slag Ballast.

Outside rail. Tie-plated. Depth of cut.	Inside rail. No plates. Depth of cut. Outside edge of base of rail.	Inside edge of base of rail.
0	$\frac{5}{16}$ in.	$\frac{3}{16}$ in.
0	$\frac{5}{16}$ in.	4-16 in.
0	$\frac{7}{16}$ in.	6-16 in.
0	$\frac{15}{32}$ in.	14-32 in.
0	$\frac{7}{16}$ in.	6-16 in.
0	8-16 in.	$\frac{7}{16}$ in.

Flanged plates were thoroughly embedded and had protected the ties from abrasion and decay.

Eastbound track, heavy traffic, white oak ties, tangent. Life five years. Furnace slag ballast.

Outside edge of base of rail.	Inside edge of base of rail.
$\frac{5}{8}$ in.	$\frac{15}{32}$ in.
$\frac{1}{2}$ in.	$\frac{1}{4}$ in.
$\frac{3}{8}$ in.	$\frac{3}{16}$ in.
$\frac{1}{2}$ in.	$\frac{1}{4}$ in.
$\frac{3}{8}$ in.	2-8 in.
$\frac{3}{4}$ in.	$\frac{9}{16}$ in.
$\frac{1}{4}$-in.	$\frac{1}{16}$ in.
$\frac{1}{2}$ in.	$\frac{3}{8}$ in.
$\frac{3}{8}$ in.	2-8 in.

Heavy traffic, tangent, white oak ties. Life six years. Gravel ballast.

Outside edge of base of rail.	Inside edge of base of rail.
1 in.	$\frac{1}{2}$ in.
1 in.	$\frac{1}{2}$ in.
1 in.	$\frac{3}{4}$ in.
1 in.	$\frac{3}{8}$ in.
1 6-8 in.	$1\frac{3}{8}$ in.
6-16 in.	$\frac{3}{16}$ in.
1 in.	$\frac{8}{16}$ in.
$1\frac{1}{4}$ in.	$\frac{3}{4}$ in.

Heavy traffic, 85-lb. A.S.C.E. rails. Five-degree curve, 5-in. x $\frac{3}{8}$-in. flanged tie-plates under outside rail in good condition, level with plane of ties.

Outside edge of base of inside rail.	Inside edge of base of inside rail.
1 in.	$\frac{1}{4}$ in.
$\frac{5}{8}$ in.	$\frac{1}{8}$ in.

Traffic light, fast passenger trains, well maintained, white oak ties

Outside edge of base of rail.	Inside edge of base of rail.	
22-32 in.	$\frac{21}{32}$ in.	2-degree curve no tie plates
6-16 in.	4-16 in.	
10-16 in.	$\frac{7}{16}$ in.	
$\frac{3}{4}$ in.	$\frac{1}{2}$ in.	
10-16 in.	$\frac{21}{32}$ in.	
$\frac{3}{4}$ in.	$\frac{1}{2}$ in.	
$\frac{9}{16}$ in.	8-16 in.	1-degree curve no tie-plates
2-16 in.	$\frac{1}{32}$ in.	
$\frac{19}{32}$ in.	$\frac{17}{32}$ in.	
2-8 in.	$\frac{1}{8}$ in.	
6-8 in.	$\frac{5}{8}$ in.	
6-16 in.	$\frac{5}{16}$ in.	
$\frac{7}{8}$ in.	$\frac{5}{8}$ in.	
$\frac{7}{16}$ in.	6-16 in.	tangent
$\frac{5}{16}$ in.	4-16 in.	
6-16 in.	6-16 in.	
12-16 in.	$\frac{11}{16}$ in.	
$\frac{7}{16}$ in.	6-16 in.	
6-16 in.	2-16 in.	8-degree curve, tie-plates on opposite end of tie. The curve generally equipped with plates, all in good condition, and level with face of tie.

DISCUSSION.

(In the absence of the Chairman, Mr. E. E. Hart, the Vice-Chairman, Mr. W. F. H. Finke, presented the report of the Committee on Ties.)

Mr. W. F. H. Finke (Southern Railway) :—This Committee has nothing to present except a progress report. After going into the matter thoroughly it was decided that this was all it should do There are no conclusions.

(Vice-President W. C. Cushing in the chair.)

Vice-President Cushing:—The Committee has no recommendations to make for consideration by the Association, but would be glad to hear any remarks with regard to the appendices which they have submitted that the members desire to make. Does anyone desire to make any remarks on the statistics of cross-ties?

We will take up Appendix A and ask for any remarks.

We will pass to Appendix B.

Prof. S. N. Williams (Cornell College) :—I would like to get as much information as possible on the subject of metal and concrete ties. If such information can be presented to the convention now, I suppose other members, like myself, would like to know the results that have been obtained.

Mr. Finke:—The Committee for several years have made reports on metal and composite ties; it was decided to get from all roads that had in use any ties of this kind a report on same. A copy of letter to the different roads and a synopsis of their reply will be found in the report. The Committee did not examine any ties that were in use except those on the Baltimore & Ohio Railroad.

In making this report it was decided to follow the same general arrangement of the replies as in the previous reports, so that it would be less confusing.

Vice-President Cushing:—I will say that the Board is making this subject a continuing subject, with the object of having the Committee report progress each year. It is very interesting information, and the Board has requested the Committee to follow up the developments in this line. I am sure the members will approve of that action after reading the interesting information which is being furnished. The Committee would appreciate it if the members would call their attention to experiments they may be conducting, and furnish them information so that they can make use of it and put it before the whole Association. Any remarks in regard to Appendix C on the use of cypress timber for ties?

Mr. Edwin F. Wendt (Pittsburg & Lake Erie) :—Before we pass Appendix B, I promised the Committee to furnish some data respecting the cost of labor in connection with the two experimental sections of track on the Pittsburg & Lake Erie Railroad. The description of these sections is found on pp. 162 and 163 of the Bulletin. This track was originally laid in 1907, and was not re-surfaced for fifteen months. In the fall of 1908 both sections were re-surfaced, the cost of labor being the cost of track labor.

Three thousand steel cross-ties, Carnegie design, with clip and bolt rail fastenings, were placed in northward freight track, McKees Rocks, Pa., in September, 1907, by the Pittsburg & Lake Erie. These steel ties are laid in a stretch of track 4,400 ft. long. The succeeding 4,400 linear ft. of the same northward freight track was laid at the same time with new No. 1 white oak ties. New steel rails, 90 lbs. A. S. C. E. section, were laid on these ties, and new limestone ballast was used throughout the entire length of 8,800 ft. of track. The track was originally surfaced in September, 1907, the depth of the ballast being about 8 in. Since that time a careful record of all labor expenses in connection with the maintenance of both steel and wooden tie sections of experimental track has been kept. After being originally built and ballasted, these two sections of track were not surfaced a second time for a period of about fifteen months. In November, 1908, both sections were re-surfaced, the cost of labor being: Cost of track labor per mile per year where wooden ties are used, $417; cost of track labor per mile per year where steel ties are used, $280. During the following 12 months these two pieces of track were simply patrolled, no labor being expended on either line of surface. In November, 1909, both stretches of track were re-surfaced, with the following result: Cost of track labor per mile per year where wooden ties are used, $95; cost of track labor per mile per year where steel ties are used, $153. During the succeeding 12 months the track with steel cross-ties was re-surfaced three times, while the track with wooden ties was re-surfaced once, with the following result: Cost of track labor per mile per year where wooden ties are used, $128; cost of track labor per mile per year where steel ties are used, $428. These experimental sections being part of the northward freight track in the four-track system, electric circuits in connection with automatic signals are in use, and it is interesting to know that during the 42 months in which these steel ties have been in use the fiber insulations have given no special signal trouble. The track at the present time is in good line and surface, and while all bolts and clip fastenings on the steel ties are tight, it is a fact that the fiber insulations are considerably worn, and this condition permits the rail to creep in the direction of traffic, which results in the ties being slewed. The drainage of this track is good. During 1909 twenty broken angle bars were removed from steel tie joints. During 1910 eighteen broken angle bars were removed from steel tie joints. The speed of trains at McKee Rocks, where this track is located, averages about thirty miles per hour.

These figures simply represent the annual results in connection with an experiment which has now been in progress three and one-half years. The data is interesting, but is not conclusive. In the early days of the experiment one character of track could be maintained with a less amount of labor, while in later times the situation was reversed. It is not apparent at this time just what the results will be at the end of the fifth, seventh or tenth year. I promised the Committee this data and have now given it.

Vice-President Cushing:—Has Mr. Jonah anything to say?

Mr. F. G. Jonah (St. Louis & San Francisco):—Nothing, except that we ask to have our labors extended another year. We hope to get some data from a number of other railways which have not yet replied to our inquiries.

Vice-President Cushing:—If there is no further discussion, the Committee will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE V.—ON TRACK.

(Bulletin 131.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

During the year your Committee held meetings as follows:

The first meeting was held at the Association rooms, Chicago, June 9 and 10, and was attended by Messrs. Raymond, Davis, Smith, Porter and Knickerbocker. The program for the year's work was laid out and the following sub-committees were appointed:

Sub-Committee "A"—Frogs and Crossings:

L. S. Rose, Chairman;
J. C. Nelson,
R. M. Pearce,
R. H. Howard,
C. H. Stein,
R. C. Falconer.

Sub-Committee "B"—Switch Points:

H. T. Porter, Chairman;
S. S. Roberts,
P. C. Newbegin,
G. J. Ray,
R. A. VanHouten,
J. R. Leighty,
T. H. Hickey.

Sub-Committee "C"—Track Fastenings with Treated Ties:

Dean Wm. G. Raymond, Chairman;
Garrett Davis,
F. A. Smith,
W. D. Wiggins,
J. L. Downs.

Sub-Committee "D"—Spirals:

J. B. Jenkins, Chairman;
Dean Wm. G. Raymond.

Mr. C. B. Hoyt was appointed member of Special Committee on Brine Drippings from Refrigerator Cars.

The second meeting was held at the A. S. C. E. rooms, New York City, September 7 and 8, and was attended by Messrs. Jenkins, Pearce, Hickey, Ray, Rose, Stein, Leighty, Roberts, Porter, Raymond and Knickerbocker. Messrs. Rudd, Ames, Anthony and Patenall represented a sub-committee from Committee X, on Signals and Interlocking, relating to switch connections in interlocking plants and frog connections at crossings and crossovers.

The third meeting was held at Congress Hotel, Chicago, October 21 and 22, and was attended by Messrs. Ray, Roberts, Raymond, Rose, Porter, Falconer, Stein and Knickerbocker. Messrs. Mock, Patenall and Elliott represented a sub-committee of Committee X, on Signals and Interlocking, and Messrs. Hatt and Kuehn a sub-committee of Committee XVII, on Wood Preservation.

The fourth meeting was held at the Association rooms, Chicago, November 17 and 18, and was attended by Messrs. Jenkins, Porter, Rose, Raymond, Smith and Knickerbocker.

REVISION OF MANUAL.

After giving that portion of the Manual pertaining to Track much discussion, it was decided that changes be recommended as follows:

(1) Maintenance of Line, section (b), for the adjustment of curves, with consideration as to easement curves.

That this paragraph be changed to read as follows:

"Longer easement curves than the minimum lengths recommended may be used to advantage, and even with increased convenience in their application, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration as to the effect on cost. *For minor curves, an increase in length of about 50 per cent. over the minimum is recommended when such increase will not seriously affect the cost, nor adversely affect the degree of curve.* The minimum length recommended should be used in all cases where greater length would adversely affect the degree of curve."

(2) Following the last paragraph under section (b).

That the following be added:

"The 10-chord spiral, computed by dividing the spiral into 10 equal parts, is recommended. Chords of any length may be used in staking out the 10-chord spiral when the central angle is small. Chords approximating one-tenth the length of spiral should be used when the central angle exceeds 15 degrees."

(3) Maintenance of Surface.

That the third paragraph following the table of elevation of the outer rail should read as follows:

"Ordinarily an elevation of eight inches should not be exceeded. *Speed of trains should be regulated to conform to the maximum elevation used."*

(4) Maintenance of Surface, section (a), recommended practice.

That the following paragraph be stricken out:

"In ordinary practice it is recommended that the elevation be run out at the rate of one inch in 60 feet, but this will be modified by the same conditions that would vary the length of the easement curve used."

(5) Maintenance of Gage, section (a).

That paragraph 1 should read as follows:

"Tie plates are recommended in all cases where economy in maintenance will result from their use."

GENERAL INSTRUCTIONS FOR ORDERING OR CONTRACTING FOR FROGS, CROSSINGS AND SWITCHES.

Manufacturers shall submit for approval detail shop drawings showing construction and dimensions of all parts to be furnished in accordance with these specifications. The drawings shall be on sheets twenty-two (22) in. wide, with a border line one-half (½) in. from the top, bottom and right-hand edge, and one and one-half (1½) in. from the left-hand edge. The standard length of drawings shall be thirty (30) in., except that, when necessary, longer sheets may be used and folded back to the standard length.

Drawings of one subject only shall appear on a sheet.

Scale of general drawings shall be 1½ in. = 1 ft., details not less than 3 in. = 1 ft. Conventional shading shall be used in sectional drawings. All dimensions and distances shall be shown plainly in figures.

The title shall be placed in the lower right-hand corner.

All drawings are intended to form a part of the specifications. Anything which is not shown on the drawings but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either, but which is reasonably implied, shall be furnished the same as if specifically shown and mentioned in both. Should anything be omitted from the drawings or specifications which is necessary for a clear understanding of the work, or should any error appear in either the drawings or specifications affecting the work, it shall be the duty of the manufacturer to notify the company and he shall not proceed with the work until instructed to do so by the company.

SWITCHES.

Lengths.

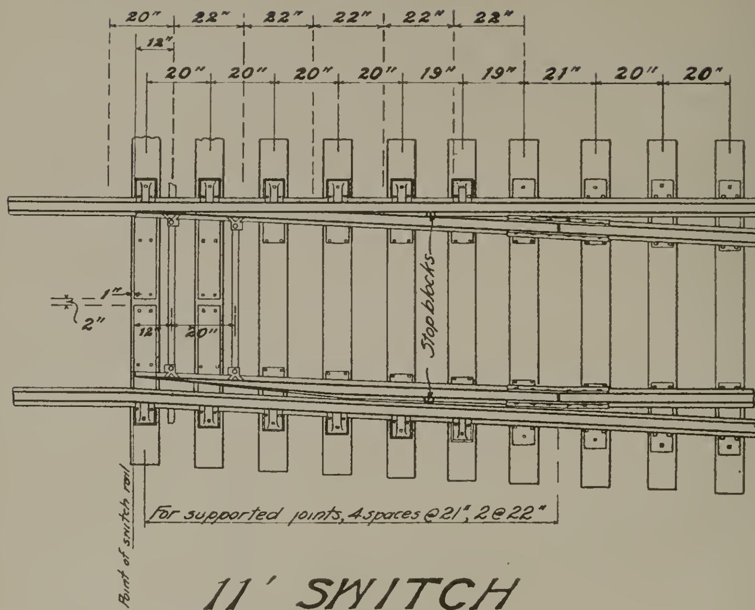
1. 11 ft., 16 ft. 6 in., 22 ft. or 33 ft.

Throw.

2. 5 in. at center line of No. 1 rod.

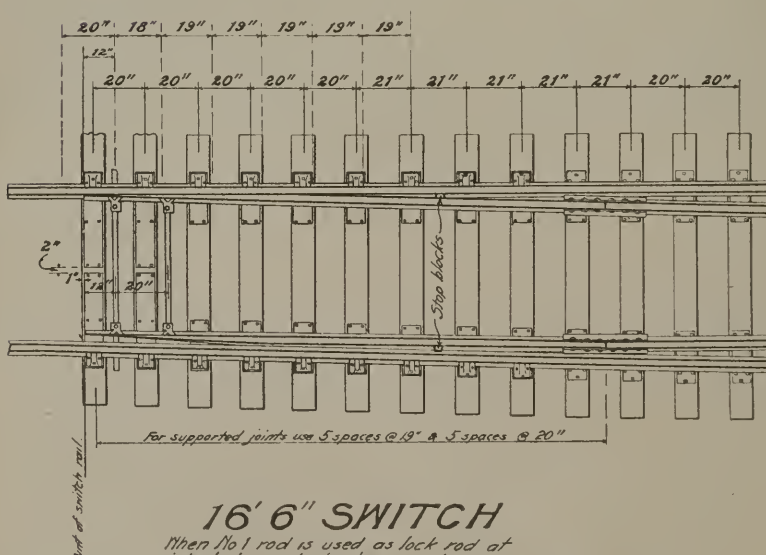
Gage of Track.

3. 4 ft. 8½ in.



11′ SWITCH

When No. 1 rod is used as lock rod at interlocking plants, ties may be spaced as shown by broken lines. Location of No 2 rod will be changed

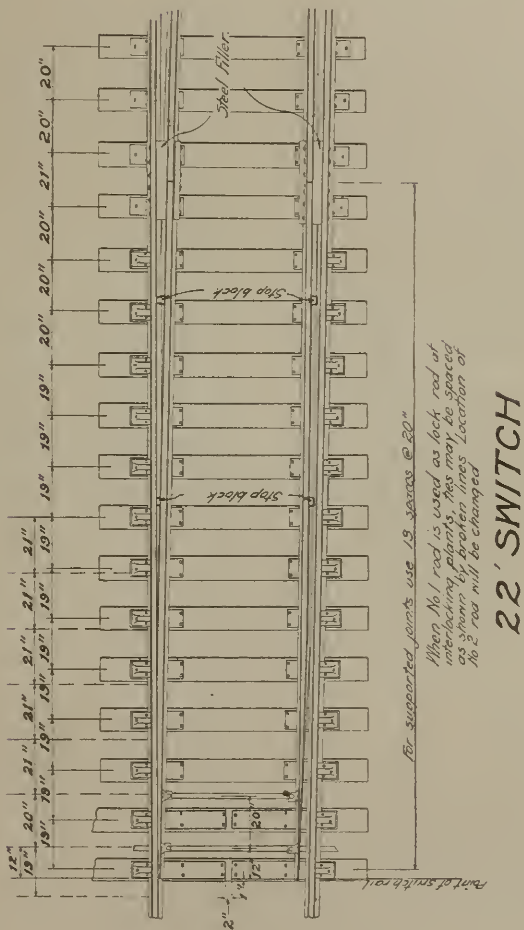


16′ 6″ SWITCH

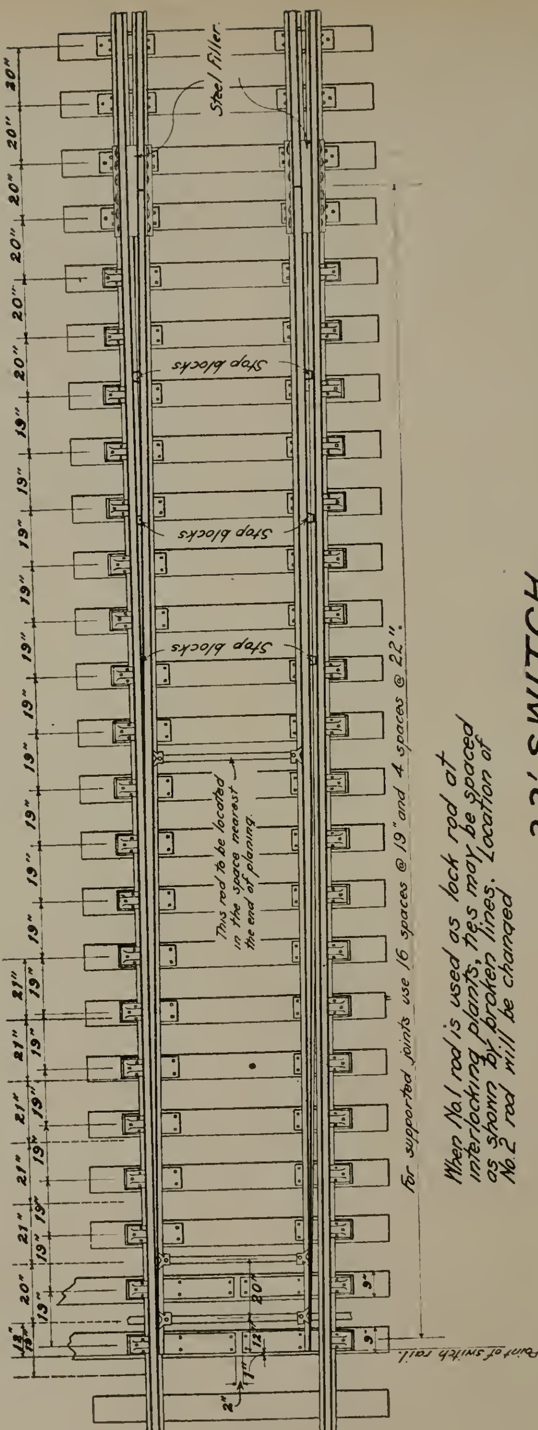
When No 1 rod is used as lock rod at interlocking plants, ties may be spaced as shown by broken lines. Location of No 2 rod will be changed

Switch Rails.

4. Side planing and bending shall conform to a spread at the heel of 6¼ in. between the gage lines of the stock rail and the switch rail. The gage lines of switch rails shall be straight. The head of switch rail shall



fit neatly against the head of stock rail from point of switch rail to point of divergence. The face of web at the point shall be in a vertical line with the inside edge of the head of stock rail.


Steel Filler.
Stop blocks
Stop blocks
Stop blocks
This rod to be located in the space nearest the end of planing.
For supported joints use 16 spaces @ 19" and 4 spaces @ 22".
When No.1 rod is used as lock rod at interlocking plants, ties may be spaced as shown by broken lines. Location of No.2 rod will be changed
Point of switch rail.

33' SWITCH

Top planing shall conform to the measurements shown on Fig. 1 and Table 1.

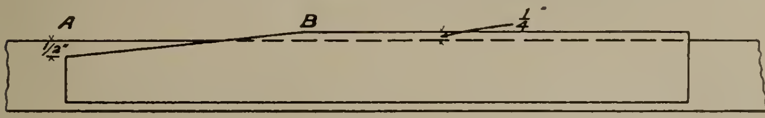


FIG. 1

TABLE 1.

Switch.	A B
33 ft.	12 ft.
22 ft.	9 ft.
16 ft. 6 in.	5 ft.
11 ft.	5 ft.

Bottom of switch rail shall be planed to fit neatly on base of stock rail where bases overlap.

The point of switch rail shall be as shown by Fig. 2.

Holes for switch rod lugs and stop blocks shall be 25/32 in. in diameter and 5 in. center to center. Holes for reinforcing bars shall be 25/32 in. diameter. Number and location as provided under Reinforcing Bars.

Lugs.

5. Lugs shall be as deep as the section of rail will permit and of standard design, as shown in Fig. —. Distance between centers of holes for bolts running through the web of the rail shall be 5 in., diameter of holes shall be 25/32 in.

*Distance between web of rail and center of switch rod bolt holes shall be 5 in. Switch rod bolt hole shall be 1 1/32 in. in diameter.

Switch Rods.

6. Switch rods shall be of the standard design, as shown in Fig. —. Rods shall be ¾x2½ in. and shall be held in a horizontal plane. Bolt holes shall be 1 1/32 in. in diameter. There shall be at least 1½ in. of metal at end beyond bolt holes.

Rods shall be stamped with ¾-in. letters showing the weight, section of rail and number of rod, the point rod being No. 1.

Reinforcing Bars.

7. A reinforcing bar ⅜-in. thick shall be riveted to each side of each switch rail and point ends shall be made flush with point of switch rail. The bars shall be as long as the heel connections will permit. Bars shall fit against web of rail and shall fill the space between head and flange of rail. There shall be ⅛-in. clearance between outer bar and head of stock rail where the bar projects under head of stock rail, and the top of inner bar, where it projects beyond the head of switch rail, shall be not less than 1⅞ in. below the top of stock rail.

Bars shall be fastened to rail with ¾-in. rivets, except that the first,

*Amend by inserting "inner face" before the word "web."

second, fifth, and the holes through which the lugs are fastened shall be bolted. Center of first hole shall be 1½ in. from point and center of last hole in bar to be 2 in. from heel end of bar. Intermediate rivets shall be spaced so that there shall be fastenings at intervals not greater than 12 inches.

Stop Blocks.

8. Stop blocks shall be of approved design with two holes 13/16 in. in diameter and 5 in. apart. Blocks shall be spaced after switch is placed in track as nearly as practicable at equal intervals between the end of planing and heel of switch.

Bolts and Nuts.

9. Bolts fastening lugs and stop blocks and foot guards to switch rails shall be ¾-in. in diameter. Bolts connecting lugs with switch rods and the switch-stand connecting bolt shall be 1 in. in diameter and machine turned. All bolts shall be provided with nut locks and cotters. Nuts shall be hexagonal.

Plates.

10. There shall be on each tie two plates, ⅞-in. by 7 in., planed down to receive the stock rail and braces. Three $\frac{15}{16}$-in. holes outside and two inside are required for ⅞-in. lag screws or screw spikes on all switch ties, except the two head ties, where there shall be three outside and four inside.

Braces.

11. Braces shall be of such a design that 2½ in. clearance for detector bars may be obtained. Three holes for ⅞-in. lag screws or screw spikes shall be provided.

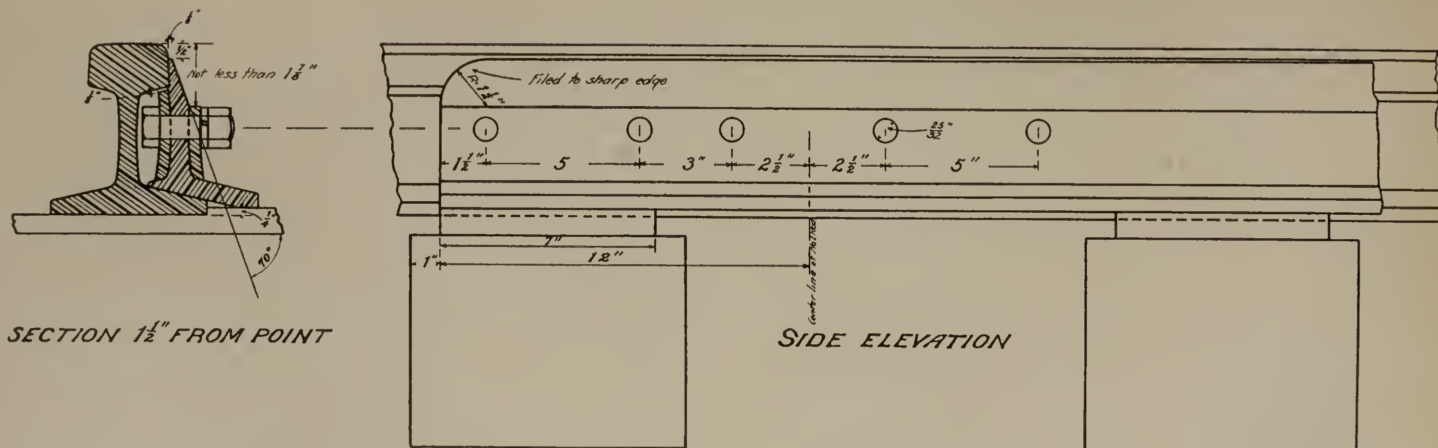


FIG. 2.

DETAILS OF POINT.

SPECIFICATIONS FOR MANGANESE IN FROGS, CROSSINGS AND SWITCH POINTS.

Your Committee has investigated so far as has been practicable this year the question of specifications for manganese in frogs, crossings and switch points. Specifications issued by the United States Government for work at Panama were reviewed; the question was taken up with some of the manufacturers of manganese work and discussed by the Committee. It was found that the manufacture of manganese castings is still in the experimental stage, that some of the manufacturers are at the present time changing their mixtures to get better results, and the Committee is not at this time in position to recommend to the Association any specifications. The Committee thinks that this subject should be further investigated and that careful records and experiments covering a period of years should be recorded before the Committee is in position to recommend a specification that will meet with your approval.

TRACK FASTENINGS WITH TREATED TIES.

Concerning track fastenings with treated ties, your Committee submits the following:

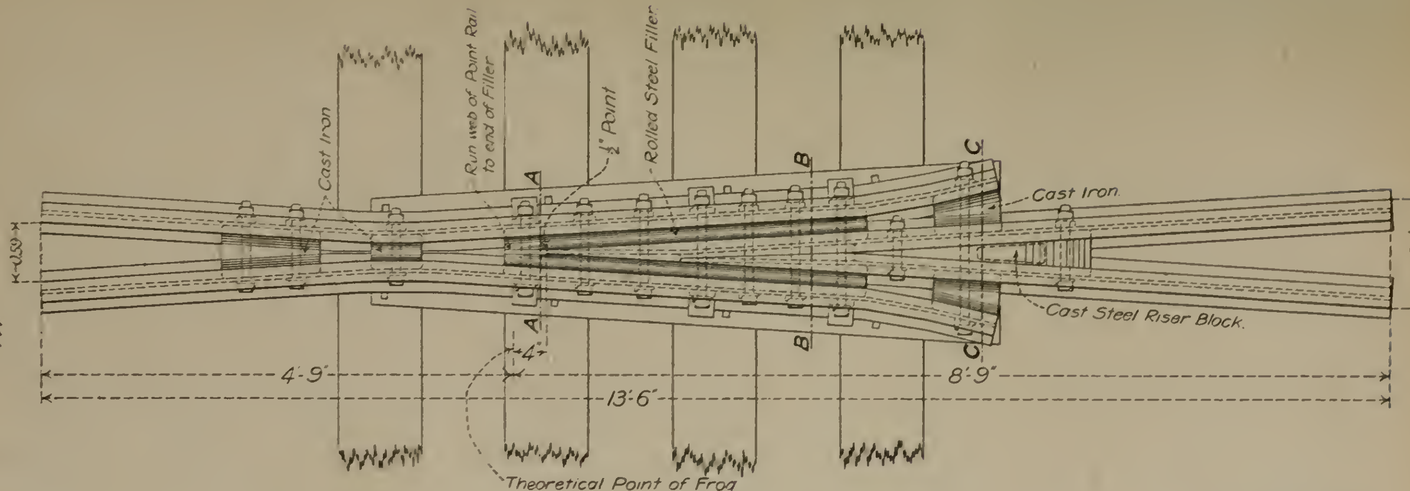
A circular letter asking for information pertinent to this subject was sent out and some 30 or more replies were received, but no information was obtained that would warrant the Committee in attempting to decide as to what is the best fastening. The Committee makes this statement with full knowledge of the excellent paper of Mr. J. W. Kendrick, read at the last meeting of the Association. This paper, without doubt, points to the screw spike used in conjunction with some form of tie-plate and with spike dowels as the best fastening yet devised, but the Committee feels that the experience with other fastenings than the common track spike, and even the experience with treated ties, has been too recent in this country to furnish data for final conclusions.

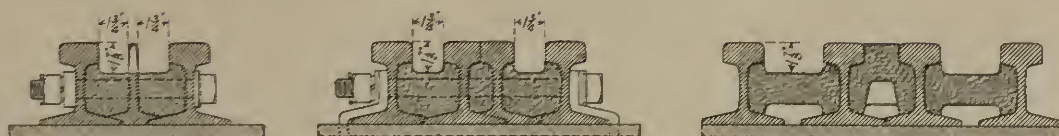
The following statements seem to be warranted by a study of the replies to the circular letters.

(1) Tie-plates with some form of fastening which can be removed and replaced at will without injury to the wood fibers are desirable. Your Committee feels that such a fastening has not as yet been fully demonstrated.

(2) In shoulder tie-plates the holes for outside fastenings should be so placed that the base of the rail bears only against the body of the fastenings.

(3) Tie-plates should be flat bottomed, as projections of any kind tend to destroy the tie. One striking photograph is shown of a treated bridge tie entirely sound except where the projections of the plate have

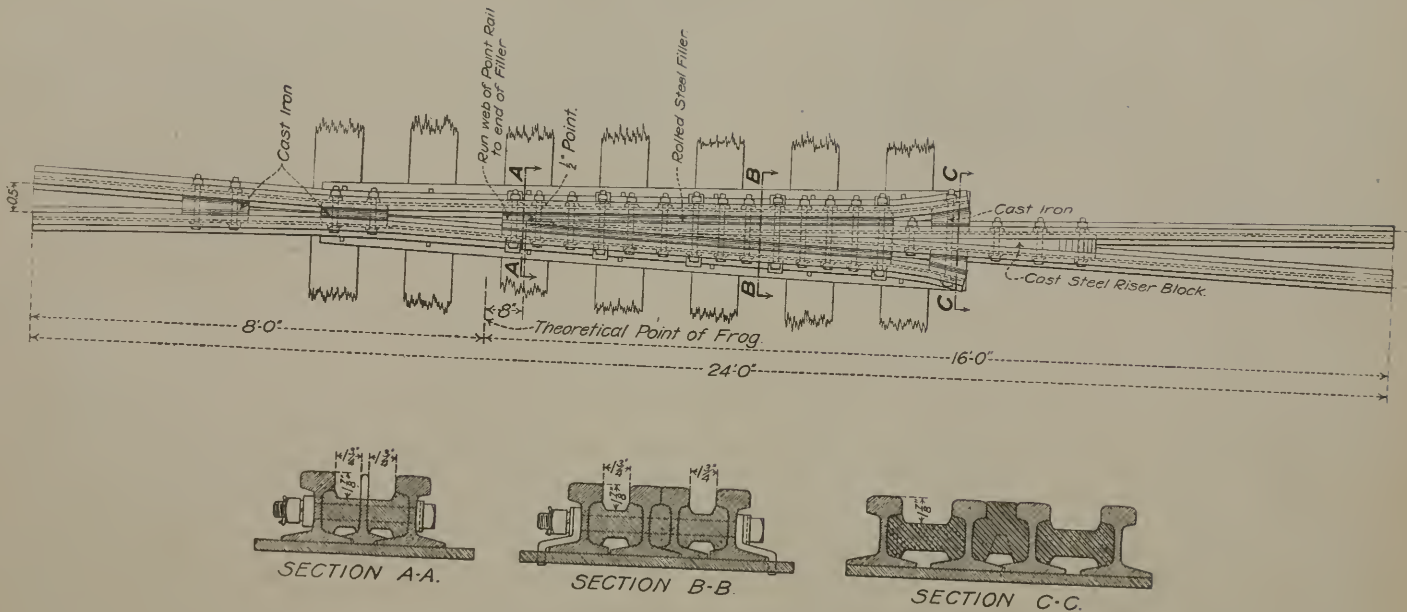




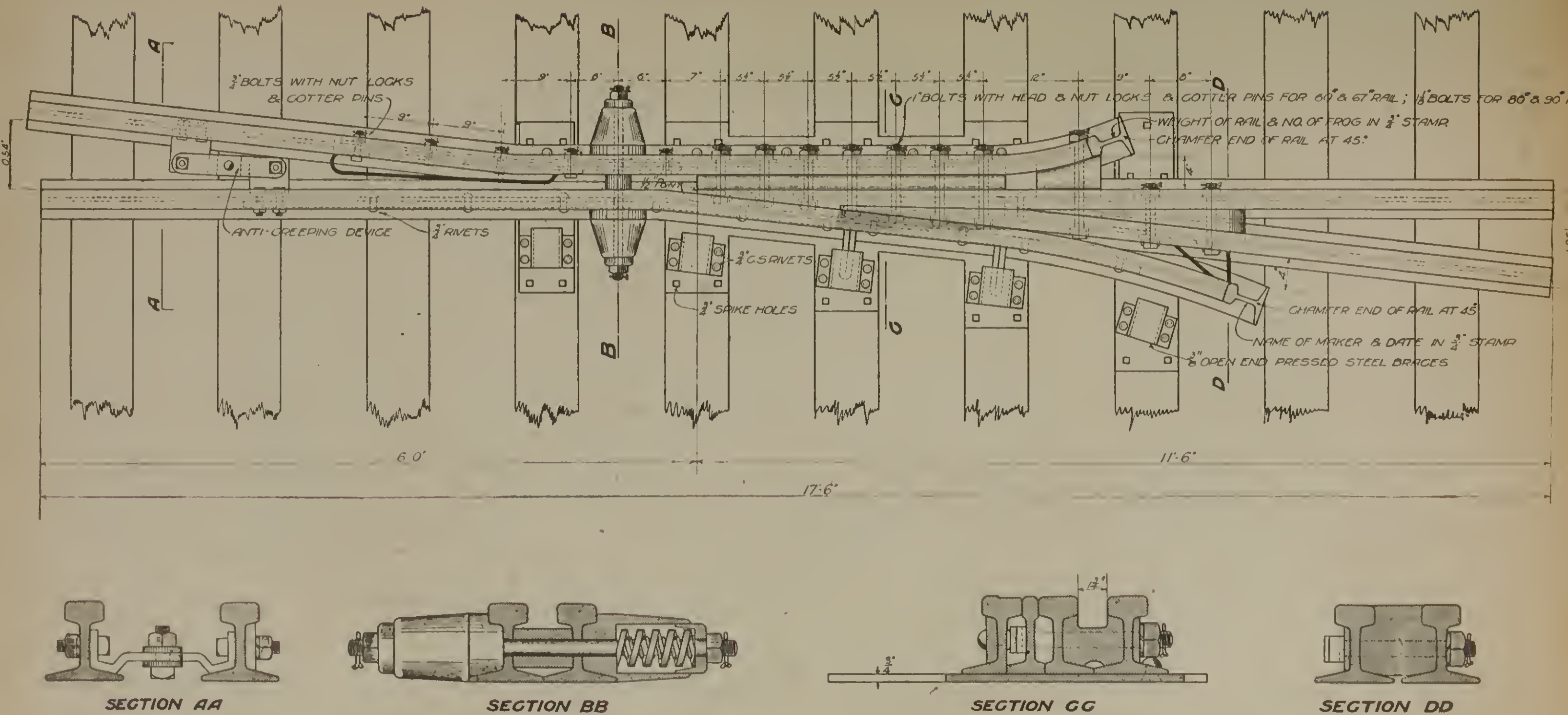
SECTION A-A SECTION B-B SECTION C-C.

Weight of Rail	Size of Frog Bolts
100	1⅛"
90	1⅛"
80	1⅛"
70	1"
60	¾"

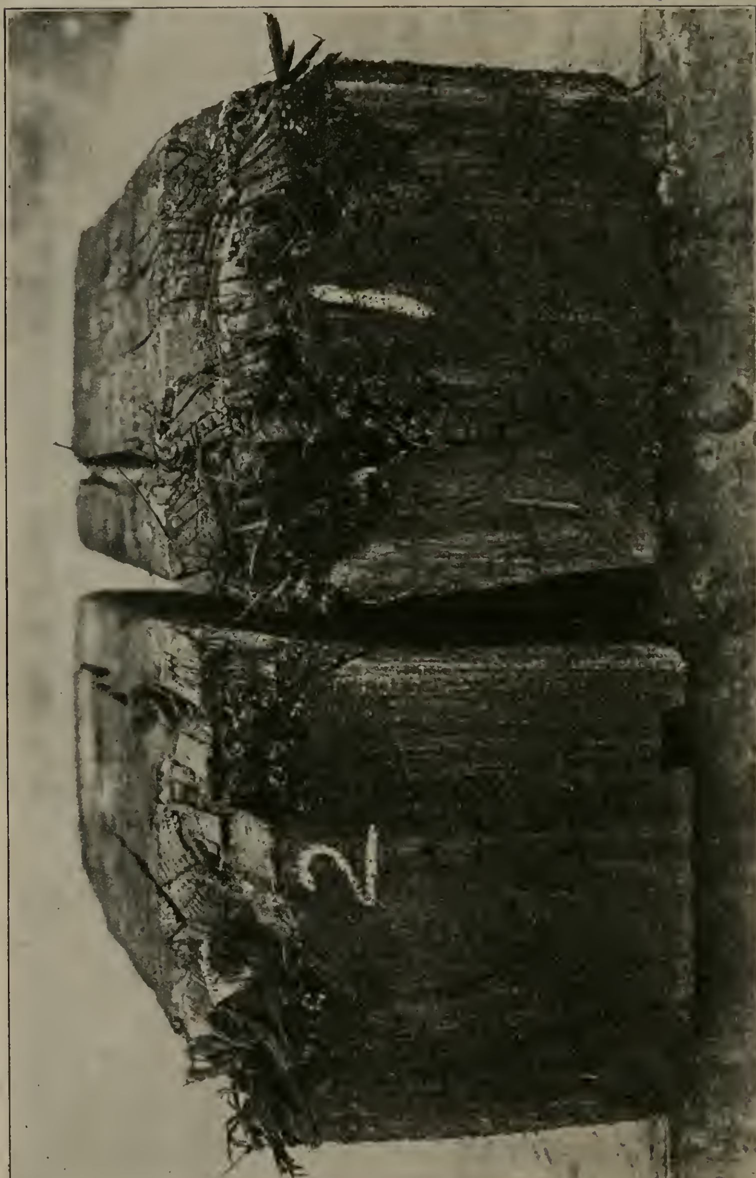
NO. 8 RIGID FROG.



NO. 16 RIGID FROG.



NO. 11 SPRING FROG.



Treated Bridge Tie—Fiber Injured by Projections of Tie-Plate.

injured the fiber. This effect would perhaps be lessened if the tie-plate were independently fastened to the tie by screws other than the rail fastenings, and by use of the principle mentioned in paragraph 5.

(4) The bearing surface of tie-plates should be proportioned by each road to the resistance of the wood most largely used for ties on its line. In general, plates six inches wide for hard woods and seven inches wide for soft woods should be sufficient, but some roads report trouble with plates of these widths.

(5) A tie-plate thicker through the whole or a part of the middle of its length than at the edges, with only a central bearing, is suggested for trial as theoretically sound. There would be less tendency for such a plate to rock under the action of the passing load and less pressure tending to force first one edge and then the other into the tie, and the plate would be strongest where the bending moment is greatest. The essentials of such a plate are the thicker central portion and the central bearing of the rail.

CONCLUSIONS.

Your Committee recommends:

(1) That the changes in the Manual, as proposed, be adopted.

(2) That the title of the specifications for spring and rigid frogs adopted by the convention of 1910 be changed to read: "General Specifications for Frogs, Crossings and Switches."

(3) That the "General Instructions for Ordering or Contracting for Frogs, Crossings and Switches," as given in the report, shall be prefixed to the specifications mentioned above.

(4) That the plans for rigid and spring frogs, submitted with the report, be adopted and added to the specifications for the frogs, crossings and switches.

(5) That the specifications for switches submitted be adopted and added to the specifications for frogs, crossings and switches.

(6) That the report on Track Fastenings used with Treated Ties be accepted as a progress report.

(7) That the report on Spirals be adopted.

Respectfully submitted,

C. E. Knickerbocker, Engineer Maintenance of Way, New York, Ontario & Western Railway, Middletown, N. Y., *Chairman.*

J. B. Jenkins, Assistant Engineer, Baltimore & Ohio Railroad, Baltimore, Md., *Vice-Chairman.*

Garrett Davis, Superintendent, Chicago, Rock Island & Pacific Railway, Eldon, Mo.

J. L. Downs, Roadmaster, Yazoo & Mississippi Valley Railroad, Vicksburg, Miss.

R. C. Falconer, Assistant Engineer, Erie Railroad, New York, N. Y.

T. H. Hickey, Roadmaster, Michigan Central Railroad, St. Thomas, Ont.

R. H. Howard, Chicago, Ill.

C. B. Hoyt, Superintendent of Track, New York, Chicago & St. Louis Railway, Bellevue, Ohio.

John R. Leighty, Engineer Maintenance of Way, Missouri Pacific Railway, Kansas City, Mo.

J. C. Nelson, Engineer Maintenance of Way, Seaboard Air Line, Norfolk, Va.

P. C. Newbegin, Maintenance Engineer, Bangor & Aroostook Railroad, Houlton, Me.

R. M. Pearce, Resident Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa.

H. T. Porter, Chief Engineer, Bessemer & Lake Erie Railroad, Greenville, Pa.

G. J. Ray, Chief Engineer, Delaware, Lackawanna & Western Railroad, Hoboken, N. J.

Wm. G. Raymond, Dean, College of Applied Science, State University of Iowa, Iowa City, Ia.

S. S. Roberts, Louisville, Ky.

L. S. Rose, Signal Engineer, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, Ohio.

C. H. Stein, Engineer Maintenance of Way, Central Railroad of New Jersey, Jersey City, N. J.

F. A. Smith, Civil Engineer, Chicago, Ill.

R. A. Van Houten, Division Engineer, Lehigh Valley Railroad, Easton, Pa.

W. D. Wiggins, Division Engineer, Pittsburg Division, Pennsylvania Lines, Pittsburg, Pa.

Committee.

Appendix A.

REPORT OF SUB-COMMITTEE ON SPIRALS.

Your Committee, in compliance with instructions, has prepared formulas for the railroad spiral.

A preliminary examination was made of a number of curves to determine their relative adaptability for use as a railroad spiral, the examination comprising (1) the cubic parabola, (2) a curve whose deflections vary as the square of the distance, (3) the Searles spiral, (4) the Stevens six-chord spiral, (5) a curve whose radius is inversely proportional to the length of arc, as developed by Crandall and Talbot, (6) a curve whose degree increases with the number of 100-ft. chords, and (7) a curve whose chords subtend a constant and inflexible series of central angles.

All the above curves accomplish the required results in easing the approach to a circular curve, some less perfectly than others, but still satisfactorily; but in attempting to derive formulas for the various spirals, some one of the following difficulties were experienced in each case:

(1) If simple, approximate formulas were used they were not sufficiently accurate.

(2) Accurate formulas were too complex.

(3) The curve could not be expressed by formulas.

(4) Formulas were of the endless-series class.

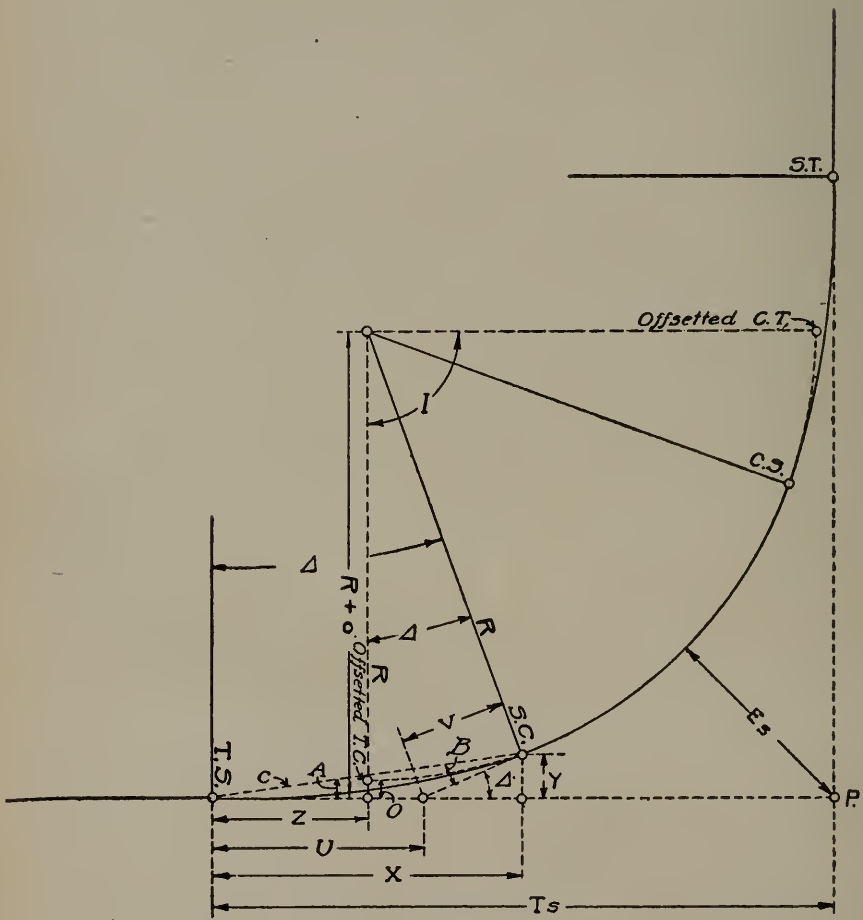
(5) Complex field methods were required to make the field work agree with formulas with spirals of large central angles.

Your Committee then investigated a practical adaptation of the spiral as developed by Crandall and Talbot in which the curve is considered to be measured by ten equal chords; this curve was found to be susceptible to expression by definite formulas which compare favorably as to simplicity with those of other spirals, the formulas being accurate beyond the degree of accuracy attainable in the most careful field work if the application of the formulas be restricted to such spirals as may actually be required in practice.

Your Committee also endeavored to establish a notation which, while adhering closely to accepted notation, shall have a logical basis. The only radical departure from the generally accepted notation is in the series of symbols for the curve points; but your committee believes the adoption of those symbols, already in use to a considerable extent, is warranted by their simplicity.

NOTATION.

For curve points, the first initial represents the alinement on the side toward station zero, the second that away from station zero.



T. C. The point of change in alinement from tangent to circular curve.
C. T. The point of change from circular curve to tangent.
C. C. The point of change in degree of circular curve; the point of compound curve, the point of reverse curve.
T. S. The point of change from tangent to spiral.
S. C. The point of change from spiral to circular curve.

C. S. The point of change from circular curve to spiral.
S. T. The point of change from spiral to tangent.
S. S. The point of change from one spiral to another.

The symbols T. C. and C. T., T. S. and S. T., and S. C. and C. S. become transposed when the direction of stationing is changed.

a The angle between the tangent at the T. S. and the chord from the T. S. to any point on the spiral.
A The angle between the tangent at the T. S. and the chord from the T. S. to the S. C.
b The angle at any point on the spiral, between the tangent at that point and the chord from the T. S.
B The angle at the S. C. between the chord from the T. S. and the tangent at the S. C.
c The chord from the T. S. to any point on the spiral.
C The chord from the T. S. to the S. C.
d The degree of curve at any point on the spiral.
D The degree of central circular curve.
f The angle between any chord of the spiral (produced if necessary) and the tangent through the T. S.
I The angle between the initial and final tangents; the total central angle of circular curve and spirals.
k The increase in degree of curve per station on the spiral.
l The length of the spiral in feet from the T. S. to any given point.
L The length of the spiral in feet from the T. S. to the S. C.
o The ordinate of the offsetted T. C.; the distance between the tangent and a parallel tangent to the offsetted curve.
r The radius of the osculating circle at any given point of the spiral.
R The radius of the central circular curve.
s The length of the spiral in stations from the T. S. to any given point.
S The length of the spiral in stations from the T. S. to the S. C.
u The distance on the tangent from the T. S. to the intersection with a tangent through any given point of the spiral.
U The distance on the tangent from the T. S. to the intersection with a tangent through the S. C.; the longer spiral tangent.
v The distance on the tangent through any given point from that point to the intersection with the tangent through the T. S.
V The distance on the tangent through the S. C. from the S. C. to the intersection with the tangent through the T. S.; the shorter spiral tangent.
x The abscissa or tangent distance of any given point, referred to the T. S.
X The abscissa or tangent distance of the S. C., referred to the T. S.
y The ordinate or tangent offset of any point.
Y The ordinate or tangent offset of the S. C.
Z The abscissa or tangent distance of the offsetted T. C., referred to the T. S.
δ The central angle of the spiral from the T. S. to any given point.

Δ The central angle of the whole spiral.
T The tangent distance of the spiraled curve; distance from T. S. to P. I. (point of intersection of tangents).
E The external distance of the offsetted curve.

FUNDAMENTAL FORMULAS.

$$\left.\begin{aligned} d &= ks = \frac{kl}{100} \\ D &= kS = \frac{kL}{100} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\left.\begin{aligned} \delta &= \frac{ks^2}{2} = \frac{ds}{2} = \frac{kl^2}{20000} = \frac{dl}{200} \\ \Delta &= \frac{kS^2}{2} = \frac{DS}{2} = \frac{kL^2}{20000} = \frac{DL}{200} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

DERIVATION OF FORMULAS.

The differential equations for the ordinates of a spiral are:

$$\left.\begin{aligned} dy &= dl \sin \delta \\ dx &= dl \cos \delta \end{aligned}\right\} \delta \text{ varying with } l^2.$$

Expanding and integrating

$$y = \frac{l\delta}{3} - \frac{l\delta^3}{42} + \frac{l\delta^5}{1320} \text{ etc.}$$

$$x = l - \frac{l\delta^2}{10} + \frac{l\delta^4}{216} \text{ etc.}$$

$$\tan a = \frac{y}{x} = \frac{\delta}{3} + \frac{\delta^3}{105} + \frac{26\,\delta^5}{155{,}925} \text{ etc.}$$

$$a = \frac{\delta}{3} - .022\,823\,\delta^3 - .000\,068\,\delta^5 \text{ etc.}$$

δ being in π measure, or radians.

Changing to degree-measure, reducing the second term to seconds and dropping all subsequent terms.

$$a = \frac{\delta}{3} - .003\,096\,\delta^3 \text{ seconds.}$$

If it be considered that the application of the spiral in actual practice is limited to central angles of less than 45°, the central angle included in the first tenth portion of such spiral will be less than 0.45°, since δ varies with the square of l or s.

So that when $l = \frac{L}{10}$, $\Delta = 45°$ and $\delta = 0.45°$,

$$a = \tfrac{1}{3}\delta - 0.00028 \text{ second.}$$

the second term being too small to affect any but a nine-place table; hence when only one-tenth of a spiral is under consideration, we may write

$$a_1 = \tfrac{1}{3}\,\delta_1, \text{ or } a_1 = \frac{\Delta}{300}$$

Dividing the spiral into ten equal parts, the angle between the tangent at the T. S. and the chord from a point (n—1) to the point (n) is the central engle of the spiral from the T. S. to the point (n—1), plus the degree of curve at the point (n—1) times half the distance in stations from (n—1) to (n), plus the deflection from the tangent at the T. S. to the chord subtending the first tenth of the spiral;

$$\text{or } f = \left(\frac{n-1}{10}\right)^2 \Delta + \frac{n-1}{100}\,\Delta + \frac{\Delta}{300}$$

$$\text{whence } f = \left(\frac{3n^2 - 3n + 1}{300}\right)\Delta,$$

substituting the successive numerals 1 to 10 for n, the successive values of f are 1, 7, 19, 37, 61, 91, 127, 169, 217, and 271-300ths of Δ.

Your Committee considers that it is advantageous to assume the spiral to be measured by a given number of equal chords, rather than along the arc, for the reason that such an assumption can be made consistent with actual field methods in staking out a spiral; if measured along the arc, we would be compelled, from a theoretical standpoint at least, to consider the chords as being of slightly varying length; and when the central angle became large, chords of varying length would actually have to be employed in the field in order to attain any reasonable degree of accuracy.

The division of a spiral into ten equal parts is quite common practice; it has a certain advantage in the simplicity of the relation between the degree of curve, length of spiral and deflections, which makes such a division very convenient; if the spiral be divided into ten equal chords instead of ten equal arcs the above advantages are retained, the field work can be made to conform with the theoretical assumption without difficulty and the resultant practical formulas are simpler than those based on the arc.

Further, it will be found that when chords of arbitrary length, such as 20, 25 or 50 feet, are used, without reference to the total length of spiral, the field work will usually conform with sufficient exactness to calculations based on the division of the spiral into ten equal chords; and in all cases a closer agreement can be attained than with calculations based on the arc.

In view of the above consideration, your Committee has developed formulas for a spiral by applying the law of angles for the chords subtending the ten equal arcs of the true spiral to the ten equal chords of what your committee calls the ten-chord spiral. L is taken as the sum of the lengths of the ten equal chords.

The angles of the chords of ten equal arcs of the "true" spiral with the initial tangent were taken to be 1, 7, 19, 37, 61, 91, 127, 169, 217 and

271-300ths of Δ. Making these angles the angles of the several chords of the ten-chord spiral with the initial tangent, we obtain

$$x_1 = \frac{L}{10} \cos \frac{1}{300} \Delta$$

$$y_1 = \frac{L}{10} \sin \frac{1}{300} \Delta$$

$$x_2 = \frac{L}{10} \left(\cos \frac{1}{300} \Delta + \cos \frac{7}{300} \Delta \right)$$

$$y_2 = \frac{L}{10} \left(\sin \frac{1}{300} \Delta + \sin \frac{7}{300} \Delta \right)$$

$$x_3 = \frac{L}{10} \left(\cos \frac{1}{300} \Delta + \cos \frac{7}{300} \Delta + \cos \frac{19}{300} \Delta \right)$$

$$X = \frac{L}{10} \left(\cos \frac{\Delta}{300} + \cos \frac{7\Delta}{300} + \cos \frac{19\Delta}{300} \ldots\ldots + \cos \frac{271\,\Delta}{300} \right)$$

$$Y = \frac{L}{10} \left(\sin \frac{\Delta}{300} + \sin \frac{7\Delta}{300} + \sin \frac{19\Delta}{300} \ldots\ldots\ldots + \sin \frac{271\Delta}{300} \right)$$

$$\tan A = \frac{Y}{X}.$$

By tabulating the values of A thus derived, with their first, second and third differences, your Committee obtained the empirical formula for the deflection angle of the complete ten-chord spiral.

$$A = \tfrac{1}{3}\Delta - 0.00297\,\Delta^2 \text{ seconds} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

in which there is no error amounting to one second and which is seen to be only slightly different from the formula of the "true" spiral

$$a = \tfrac{1}{3}\delta - .003096\,\delta^2 \text{ seconds, etc.}$$

From definition,

$$B = \Delta - A \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The linear functions of the spiral have very simple trigonometrical relations by which any function can be readily calculated when any one linear function other than L, and the three angles Δ, A and B are known; but in order to obtain the most accurate solution, the largest function, C, should be determined, and used in obtaining the remaining functions.

Obtaining C from $C^2 = X^2 + Y^2$ or from $C = \dfrac{X}{\cos A}$ and comparing the results for the different values of Δ, we find that the formula

$$C = L\,(\cos 0.3\,\Delta + .004 \operatorname{exsec} \tfrac{3}{4}\,\Delta) \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

will give results with no error exceeding one part in one million.

As errors in (3) and (5) are less than the unavoidable errors of measurement when field work is done with the utmost precision, these two formulas will be considered as being exact; the two primary formulas

$$Y = \frac{L}{10}\left(\sin\frac{\Delta}{300} + \sin\frac{7\Delta}{300} \ldots\ldots\ldots + \sin\frac{271\Delta}{300}\right)$$

$$\text{and } X = \frac{L}{10}\left(\cos\frac{\Delta}{300} + \cos\frac{7\Delta}{300} \ldots\ldots\ldots + \cos\frac{271\Delta}{300}\right)$$

are discarded as being too cumbersome and these functions derived from the formulas

$$X = C \cos A \ldots\ldots \quad (6)$$

$$\text{and } Y = C \sin A \ldots\ldots \quad (7)$$

The formulas for the remaining functions follow from their very simple trigonometrical relations:

$$U = C\frac{\sin B}{\sin \Delta} \ldots\ldots \quad (8)$$

$$V = C\frac{\sin A}{\sin \Delta} \ldots\ldots \quad (9)$$

$$R = \frac{50}{\sin \frac{1}{2} D} \ldots\ldots \quad (10)$$

$$Z = X - R \sin \Delta \ldots\ldots \quad (11)$$

$$o = Y - R \text{ vers } \Delta \ldots\ldots \quad (12)$$

$$T_s = (R + o) \tan (\tfrac{1}{2} I) + Z \ldots\ldots \quad (13)$$

$$E_s = (R + o) \text{ exsec } (\tfrac{1}{2} I) + o \ldots\ldots \quad (14)$$

The above are the functions of the completed spiral; with these formulas we can, without great labor, determine all the functions of any spiral when any two of the four quantities D, k, Δ and L are known; from these formulas tables of several of the functions have been computed and are appended to this report.

The radius at the S. C. of the spiral thus developed will exceed that of the spiral in which the radius is inversely proportional to the length of the spiral measured along the curve, but will be less than the radius of the central circular curve. In the almost impossible case of a spiral 1,000 feet long the radius at S. C. will equal that of the central circular curve.

It is evident that the formulas for the completed spirals will not theoretically apply to any given point within a spiral; that is to say, formulas for X, Y, etc., will not theoretically give the correct values for x, y, etc., but as the intermediate points of a spiral are only used for lining track, such a discrepancy, even if considerable, would not be objectionable.

Such discrepancies, however, will be seen to be trivial from the following comparisons, the first from a fairly representative case, the second from an extreme case not likely to occur in practice; in these comparisons x and y are the correctly determined co-ordinates of the ten chord-points of the two spirals used for comparison, while X and Y are the co-ordinates of complete spirals, having the same rate k and total lengths corresponding to the lengths to the ten respective chord-points.

Spiral 500 ft. long to a 4° curve (k = 0.8).

L	Δ	X	Y	l	δ	x	Diff.	y	Diff.
50	0° 06′	50.000	0.029	50	0° 06′	50.000	......	0.029	......
100	0° 24′	100.000	0.233	100	0° 24′	100.000	......	0.233	......
150	0° 54′	149.996	0.785	150	0° 54′	149.996	......	0.785	......
200	1° 36′	199.985	1.862	200	1° 36′	199.985	......	1.862	......
250	2° 30′	249.953	3.636	250	2° 30′	249.953	......	3.636	......
300	3° 36′	299.882	6.281	300	3° 36′	299.883	+.001	6.281	......
350	4° 54′	349.746	9.972	350	4° 54′	349.747	+.001	9.972	......
400	6° 24′	399.504	14.880	400	6° 24′	399.506	+.002	14.880	......
450	8° 06′	449.107	21.176	450	8° 06′	449.108	+.001	21.176	......
500	10° 00′	498.488	29.026	500	10° 00′	498.488	......	29.026	......

Spiral 250 ft. long to a 32° curve (k = 12.8).

L	Δ	X	Y	l	δ	x	Diff.	y	Diff.
25	0° 24′	25.000	0.058	25	0° 24′	25.000	......	0.058	......
50	1° 36′	49.996	0.465	50	1° 36′	49.996	......	0.465	......
75	3° 36′	74.971	1.570	75	3° 36′	74.972	+.001	1.570	......
100	6° 24′	99.876	3.720	100	6° 24′	99.879	+.003	3.720	......
125	10° 00′	124.622	7.257	125	10° 00′	124.628	+.006	7.257	......
150	14° 24′	149.061	12.511	150	14° 24′	149.069	+.008	12.512	+.001
175	19° 36′	172.974	19.791	175	19° 36′	172.985	+.011	19.793	+.002
200	25° 36′	196.065	29.370	200	25° 36′	196.077	+.012	29.374	+.004
225	32° 24′	217.948	41.465	225	32° 24′	217.956	+.008	41.468	+.003
250	40° 00′	238.148	56.210	250	40° 00′	238.148	......	56.210	......

FORMULAS FOR FIELD USE.

The formulas presented above are best adapted for the preparation of tables. For use in the field, the following empirical formulas are sufficiently accurate and have the advantage that they do not require the computation of the long chord. The formulas can all be applied for the functions of any parts of the spiral without serious error, though they are derived for the completed spiral.

$$\left.\begin{aligned} a &= \tfrac{1}{3}\,\delta \\ A &= \tfrac{1}{3}\,\Delta \end{aligned}\right\} \qquad (15)$$

$$\left.\begin{aligned} a &= 10\,ks^2 \text{ minutes} \\ A &= 10\,kS^2 \text{ minutes} \end{aligned}\right\} \qquad (16)$$

Formulas (15) and (16) are sufficiently accurate for turning deflections when δ (or Δ) does not exceed 15°.

A similar approximation may be used when the transit is set at an intermediate point on the spiral if the included central angle from the transit point to the point of sight, less the included angle from the T. S. to the transit point, does not exceed 15°.

$$X = L - L\left(\tfrac{1}{3}\text{ vers }\tfrac{3}{4}\,\Delta + 1/22\text{ vers }\tfrac{1}{2}\,\Delta\right) \qquad (17)$$

$$Y = \frac{L}{39}\left(20 \sin \tfrac{1}{2}\,\Delta + 3 \sin \Delta\right) \qquad (18)$$

$$U = L\left(\tfrac{2}{3} + \tfrac{10}{39}\text{ exsec }\tfrac{1}{2}\,\Delta + 1/10\text{ vers }\tfrac{1}{4}\,\Delta\right) \qquad (19)$$

$$V = L\left(\tfrac{1}{3} + \tfrac{10}{39}\text{ exsec }\tfrac{1}{2}\,\Delta\right) \qquad (20)$$

$$o = \frac{L}{10}(\sin \tfrac{1}{2}\Delta + \sin \tfrac{1}{3}\Delta)\cos \tfrac{1}{2} D \ldots\ldots\ldots\ldots (21)$$

$$Z = L\,(0.5 - .12885 \text{ vers } \tfrac{1}{2}\Delta) - .073\, D \sin \Delta \ldots\ldots (22)$$

$$L = \frac{370.82}{\cos \frac{21}{60} D}(1 + .000018\, Do)\sqrt{\frac{o}{D}} \ldots\ldots\ldots\ldots (23)$$

The errors in the application of the above empirical formulas are as tabulated below:

Errors—Millionths of L.

Δ	(17)	(18)	(19)	(20)
5°	None	None	None	None
10°	None	None	None	None
15°	None	None	None	None
20°	+ 1	None	None	None
25°	+ 2	None	None	None
30°	+ 3	None	+2	None
35°	+ 6	None	+4	None
40°	+ 9	—1	+6	—2
45°	+14	—3	+8	—5

The errors in (21), (22) and (23) are dependent on both Δ and D and are given for the following wide range of cases, including not only a sufficient range within probable practice, but also in a number of cases which are so unusual that they might be considered purely imaginary.

Values in feet of o, Z and L, with errors in using formulas (21), (22) and (23).

D	Δ	o	Error (21)	Z	Error (22)	L	Error (23)
1	5	7.270	None	499.871	—.002	1 000.000	—.001
2	5	3.635	None	249.926	None	500.000	—.005
2	10	14.528	None	499.485	None	1 000.000	+.017
5	5	1.453	None	99.944	None	200.000	+.003
5	10	5.806	None	199.741	None	400.000	—.004
5	15	13.049	None	299.245	—.001	600.000	+.035
5	20	23.159	—.002	398.310	—.001	800.000	—.090
10	5	0.724	None	49.924	None	100.000	—.002
10	10	2.895	None	99.775	None	200.000	—.018
10	15	6.506	None	149.481	None	300.000	—.017
10	20	11.546	None	198.968	—.001	400.000	—.035
10	25	18.002	—.002	248.166	—.001	500.000	+.072
15	15	4.316	None	99.497	—.001	200.000	—.006
15	30	17.155	—.003	197.697	—.001	400.000	+.075
20	10	1.431	None	49.698	None	100.000	—.020
20	15	3.216	None	74.457	None	150.000	—.021
20	20	5.707	None	99.109	None	200.000	—.038
20	25	8.898	—.001	123.620	None	250.000	—.005
20	30	12.780	—.003	147.953	None	300.000	+.021
20	35	17.342	—.007	172.075	None	350.000	+.034
20	40	22.572	—.014	195.953	None	400.000	—.023
30	15	2.102	—.001	49.321	+.002	100.000	—.086
30	30	8.356	—.003	98.022	+.005	200.000	—.065
30	45	18.610	—.021	145.502	+.008	300.000	+.024
40	20	2.720	+.003	48.795	+.010	100.000	—.154
40	30	6.092	+.004	72.866	+.015	150.000	—.193
40	40	10.766	—.004	96.549	+.024	200.000	—.191

STAKING SPIRALS BY DEFLECTIONS.

The entire spiral may be run by deflections from the T. S., using the formula $a = 10\,ks^2$ minutes, when Δ does not exceed 15°.

When Δ exceeds 15°, formula (3) should be used or else an additional transit point used between the T. S. and the S. T.

In the latter case the method of obtaining the deflection angles is more simply described than expressed by formula.

The deflection angle from a tangent through a point P′ to a point P″ is the deflection for the degree of curve at P′ for the distance P′ P″ plus or minus the initial spiral deflection angle for the distance P′ P″.

Let d′ be the degree of curve at P′, s′ the distance in stations from the T. S. to P′ and s″ the distance in stations from the T. S. to P″. Then the deflection $(f - \delta')$ is expressed by the formula

$$f - \delta' = \frac{d'}{2}(s'' - s') + \frac{k}{6}(s'' - s')^2$$

which gives numerical results identical with the verbal rule given above; no attention need be paid to the algebraic sign of the result, as the direction of the deflection is known; or it can be expressed as

$$f - \delta' = \frac{1}{6}(2d' + d'')\ (s'' - s')$$

This rule applies equally to spirals run in from any point on spiral, from the S. T., or to a spiral connecting two circular curves, the latter being simply the requisite portion of the ordinary spiral. The formulas and rule are approximate and should not be used when the central angle from P′ to P″ exceeds the central angle from the T. S. to P′ by more than 15°.

In staking by deflections, considerable convenience is sometimes found in dividing the spiral in ten equal chords, conforming to the theory upon which your committee has based its formulas. The first deflection in minutes equals the degree of the main or central curve times the length of chord in stations. For example, for a spiral $L = 500$, $D = 4°$, $s_1 = 0.5$ and $a_1 = 4 \times 0.5 = 2$ minutes; the remaining deflections are 4, 9, 16, 25, etc., times the initial deflection.

The following table gives the coefficients by which a_1 — the first chord deflection — is to be multiplied to give the deflections to other chord points for various positions of the transit.

Coefficients of a_1 for Deflections to Chord Points

Transit at Chord Point	Deflections to Chord-Point Number										
	0	1	2	3	4	5	6	7	8	9	10
0 T. S.	0	1	4	9	16	25	36	49	64	81	100
1	2	0	4	10	18	28	40	54	70	88	108
2	8	5	0	7	16	27	40	55	72	91	112
3	18	14	8	0	10	22	36	52	70	90	112
4	32	27	20	11	0	13	28	45	64	85	103
5	50	44	36	26	14	0	16	34	54	76	100
6	72	65	56	45	32	17	0	19	40	63	88
7	98	90	80	68	54	38	20	0	22	46	72
8	128	119	108	95	80	63	44	23	0	25	52
9	162	152	140	126	110	92	72	50	26	0	28
10 S. C.	200	189	176	161	144	125	104	81	56	29	0

STAKING SPIRALS BY OFFSETS.

The spiral may be staked by offsets, one half being offsetted from the tangent and the other half from the circular curve, by making the offsets vary directly as the cube of the distance from the T. S. and the S. C. This should be done either by using right angle and normal offsets, making the right angle or normal offset for the middle point of the spiral equal ½ o; or else by measuring half the total length of the spiral along the tangent, bisecting the distance to the offsetted T. C. for the offset to the middle point of spiral and using oblique offsets between equidistant points on the tangent or circular curve and equidistant points on the spiral.

Both methods will produce spirals somewhat at variance with any theoretical curve, but the variations are of no practical consequence.

If closer adherence to the theoretical curve is desired, the entire spiral may be staked from the tangent by use of the co-ordinates x and y.

Your Committee submits herewith a diagram indicating graphically the Minimum Length of Easement Curve as recommended by the Association.

Your Committee also submits a discussion by Mr. Frank H. Carter on the selection of length of transition spirals.

Your Committee recommends the adoption of the foregoing formulas (1) to (14), inclusive, for the exact determination of the functions of spirals whose central angles do not exceed 45° and formulas (15) to (23), inclusive, for field use.

Your Committee recommends that the drawing of a spiral, the recommended Notation, the diagram of "Minimum Length of Easement Curve," the table of "Functions of the Ten-chord Spiral" and the table of "Coefficients for Deflection to Chord-points" be printed in the Manual.

Your Committee recommends the following changes in the Manual of Recommended Practice, indicated by boldface type:

MAINTENANCE OF LINE AND ALINEMENT.

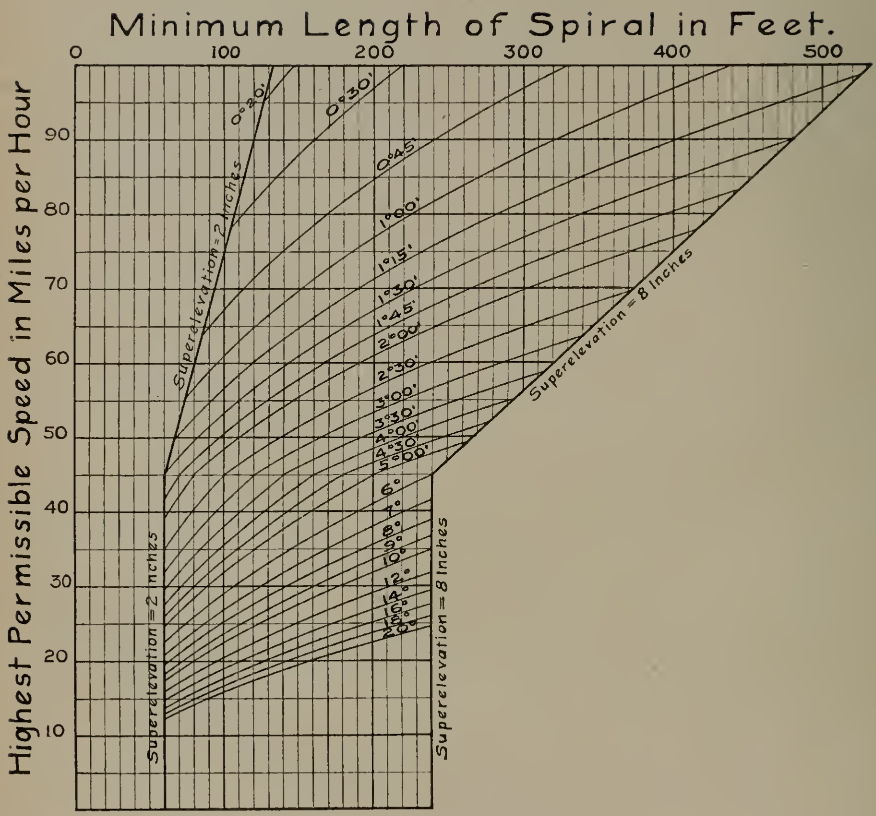
(b) Adjustment of Curves, with consideration as to Easement Curves:

Longer easement curves than the minimum lengths recommended may be used to advantage and often with increased convenience in their application, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration as to the effect on cost. *For minor curves, an increase in length of about 50 per cent. over the minimum is recommended when such increase will not seriously affect the cost, nor adversely affect the degree of curve.*

The minimum length recommended should be used in all cases where a greater length would adversely affect the degree of curve.

(Following the last paragraph.)

The ten-chord spiral, computed by dividing the spiral into ten equal chords, is recommended. Chords of any length may be used in staking out the ten-chord spiral when the central angle is small. Chords approximating one-tenth the length of spiral should be used when the central angle exceeds fifteen degrees.



MINIMUM LENGTH OF EASEMENT CURVE.

Limiting Curves.

For all curves which are liable to limit the speed of trains, the length of spiral should equal that indicated on the line marked "Superelevation=8 inches." Longer spirals may be used provided the increased length does not adversely affect the degree of curve or seriously affect the cost of construction.

Minor Curves.

For minor curves the length of spiral should never be less than that indicated by the diagram; an increase of about 50 per cent. over the indicated length may be desirable where cost is not seriously affected.

Spirals need not be used when superelevation required for highest permissible speed is less than two inches.

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.

Δ	A	C/L	X/L	Y/L
0.0°	0° 00′ 00″	1.000 000	1.000 000	.000 000
0.1°	0° 02′ 00″	1.000 000	1.000 000	.000 582
0.2°	0° 04′ 00″	.999 999	.999 999	.001 164
0.3°	0° 06′ 00″	.999 999	.999 997	.001 745
0.4°	0° 08′ 00″	.999 998	.999 995	.002 327
0.5°	0° 10′ 00″	.999 997	.999 993	.002 909
0.6°	0° 12′ 00″	.999 995	.999 989	.003 491
0.7°	0° 14′ 00″	.999 993	.999 985	.004 072
0.8°	0° 16′ 00″	.999 991	.999 981	.004 654
0.9°	0° 18′ 00″	.999 989	.999 975	.005 236
1.0°	0° 20′ 00″	.999 987	.999 970	.005 818
1.1°	0° 22′ 00″	.999 984	.999 963	.006 399
1.2°	0° 24′ 00″	.999 981	.999 956	.006 981
1.3°	0° 26′ 00″	.999 977	.999 949	.007 563
1.4°	0° 28′ 00″	.999 974	.999 941	.008 145
1.5°	0° 30′ 00″	.999 970	.999 932	.008 726
1.6°	0° 32′ 00″	.999 966	.999 923	.009 308
1.7°	0° 34′ 00″	.999 961	.999 913	.009 890
1.8°	0° 36′ 00″	.999 957	.999 902	.010 471
1.9°	0° 38′ 00″	.999 952	.999 891	.011 053
2.0°	0° 40′ 00″	.999 947	.999 879	.011 635
2.1°	0° 42′ 00″	.999 941	.999 867	.012 216
2.2°	0° 44′ 00″	.999 935	.999 853	.012 798
2.3°	0° 46′ 00″	.999 929	.999 840	.013 379
2.4°	0° 48′ 00″	.999 923	.999 826	.013 961
2.5°	0° 50′ 00″	.999 916	.999 811	.014 542
2.6°	0° 52′ 00″	.999 910	.999 795	.015 124
2.7°	0° 54′ 00″	.999 903	.999 779	.015 706
2.8°	0° 56′ 00″	.999 895	.999 763	.016 287
2.9°	0° 58′ 00″	.999 888	.999 745	.016 868
3.0°	1° 00′ 00″	.999 880	.999 727	.017 450
3.1°	1° 02′ 00″	.999 872	.999 709	.018 031
3.2°	1° 04′ 00″	.999 863	.999 690	.018 613
3.3°	1° 06′ 00″	.999 854	.999 670	.019 194
3.4°	1° 08′ 00″	.999 845	.999 650	.019 776
3.5°	1° 10′ 00″	.999 836	.999 629	.020 357
3.6°	1° 12′ 00″	.999 827	.999 607	.020 938
3.7°	1° 14′ 00″	.999 817	.999 585	.021 519
3.8°	1° 16′ 00″	.999 807	.999 563	.022 101
3.9°	1° 18′ 00″	.999 797	.999 539	.022 682
4.0°	1° 20′ 00″	.999 786	.999 515	.023 263
4.1°	1° 22′ 00″	.999 775	.999 491	.023 844
4.2°	1° 24′ 00″	.999 764	.999 466	.024 425
4.3°	1° 26′ 00″	.999 753	.999 440	.025 006
4.4°	1° 28′ 00″	.999 741	.999 414	.025 588
4.5°	1° 30′ 00″	.999 729	.999 387	.026 169
4.6°	1° 32′ 00″	.999 717	.999 359	.026 750
4.7°	1° 34′ 00″	.999 705	.999 331	.027 330
4.8°	1° 36′ 00″	.999 692	.999 302	.027 911
4.9°	1° 38′ 00″	.999 679	.999 273	.028 492
5.0°	1° 40′ 00″	.999 666	.999 243	.029 073

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
5.0°	1° 40′ 00″	.999 666	.999 243	.029 073
5.1°	1° 42′ 00″	.999 652	.999 212	.029 654
5.2°	1° 44′ 00″	.999 639	.999 181	.030 235
5.3°	1° 46′ 00″	.999 625	.999 149	.030 816
5.4°	1° 48′ 00″	.999 610	.999 117	.031 396
5.5°	1° 50′ 00″	.999 596	.999 084	.031 977
5.6°	1° 51′ 59″	.999 581	.999 051	.032 558
5.7°	1° 53′ 59″	.999 566	.999 016	.033 138
5.8°	1° 55′ 59″	.999 550	.998 982	.033 719
5.9°	1° 57′ 59″	.999 535	.998 946	.034 299
6.0°	1° 59′ 59″	.999 519	.998 910	.034 880
6.1°	2° 01′ 59″	.999 503	.998 873	.035 460
6.2°	2° 03′ 59″	.999 486	.998 836	.036 040
6.3°	2° 05′ 59″	.999 470	.998 799	.036 621
6.4°	2° 07′ 59″	.999 453	.998 760	.037 201
6.5°	2° 09′ 59″	.999 435	.998 721	.037 781
6.6°	2° 11′ 59″	.999 418	.998 681	.038 361
6.7°	2° 13′ 59″	.999 400	.998 641	.038 941
6.8°	2° 15′ 59″	.999 382	.998 600	.039 522
6.9°	2° 17′ 59″	.999 364	.998 559	.040 102
7.0°	2° 19′ 59″	.999 345	.998 517	.040 681
7.1°	2° 21′ 59″	.999 326	.998 474	.041 261
7.2°	2° 23′ 59″	.999 307	.998 431	.041 841
7.3°	2° 25′ 59″	.999 288	.998 387	.042 421
7.4°	2° 27′ 59″	.999 268	.998 343	.043 001
7.5°	2° 29′ 59″	.999 248	.998 298	.043 581
7.6°	2° 31′ 59″	.999 228	.998 252	.044 160
7.7°	2° 33′ 59″	.999 208	.998 206	.044 740
7.8°	2° 35′ 59″	.999 187	.998 159	.045 319
7.9°	2° 37′ 59″	.999 166	.998 111	.045 899
8.0°	2° 39′ 58″	.999 145	.998 063	.046 478
8.1°	2° 41′ 58″	.999 123	.998 015	.047 058
8.2°	2° 43′ 58″	.999 102	.997 965	.047 637
8.3°	2° 45′ 58″	.999 080	.997 916	.048 216
8.4°	2° 47′ 58″	.999 057	.997 865	.048 795
8.5°	2° 49′ 58″	.999 035	.997 814	.049 374
8.6°	2° 51′ 58″	.999 012	.997 762	.049 953
8.7°	2° 53′ 58″	.998 989	.997 710	.050 532
8.8°	2° 55′ 58″	.998 965	.997 657	.051 111
8.9°	2° 57′ 58″	.998 942	.997 603	.051 690
9.0°	2° 59′ 58″	.998 918	.997 549	.052 269
9.1°	3° 01′ 58″	.998 894	.997 494	.052 848
9.2°	3° 03′ 58″	.998 869	.997 439	.053 426
9.3°	3° 05′ 58″	.998 844	.997 383	.054 005
9.4°	3° 07′ 58″	.998 819	.997 327	.054 583
9.5°	3° 09′ 57″	.998 794	.997 270	.055 162
9.6°	3° 11′ 57″	.998 769	.997 212	.055 740
9.7°	3° 13′ 57″	.998 743	.997 154	.056 318
9.8°	3° 15′ 57″	.998 717	.997 095	.056 897
9.9°	3° 17′ 57″	.998 691	.997 035	.057 475
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
10.0°	3° 19′ 57″	.998 664	.996 975	.058 053
10.1°	3° 21′ 57″	.998 637	.996 915	.058 631
10.2°	3° 23′ 57″	.998 610	.996 853	.059 209
10.3°	3° 25′ 57″	.998 583	.996 791	.059 787
10.4°	3° 27′ 57″	.998 555	.996 729	.060 364
10.5°	3° 29′ 57″	.998 527	.996 666	.060 942
10.6°	3° 31′ 56″	.998 499	.996 602	.061 520
10.7°	3° 33′ 56″	.998 471	.996 538	.062 097
10.8°	3° 35′ 56″	.998 442	.996 473	.062 675
10.9°	3° 37′ 56″	.998 413	.996 407	.063 252
11.0°	3° 39′ 56″	.998 384	.996 341	.063 829
11.1°	3° 41′ 56″	.998 354	.996 274	.064 406
11.2°	3° 43′ 56″	.998 324	.996 207	.064 984
11.3°	3° 45′ 56″	.998 294	.996 139	.065 561
11.4°	3° 47′ 56″	.998 264	.996 071	.066 138
11.5°	3° 49′ 55″	.998 233	.996 002	.066 714
11.6°	3° 51′ 55″	.998 203	.995 932	.067 291
11.7°	3° 53′ 55″	.998 172	.995 862	.067 868
11.8°	3° 55′ 55″	.998 140	.995 791	.068 445
11.9°	3° 57′ 55″	.998 109	.995 719	.069 021
12.0°	3° 59′ 55″	.998 077	.995 647	.069 598
12.1°	4° 01′ 55″	.998 044	.995 574	.070 174
12.2°	4° 03′ 55″	.998 012	.995 501	.070 750
12.3°	4° 05′ 54″	.997 979	.995 427	.071 326
12.4°	4° 07′ 54″	.997 946	.995 353	.071 902
12.5°	4° 09′ 54″	.997 913	.995 278	.072 478
12.6°	4° 11′ 54″	.997 880	.995 202	.073 054
12.7°	4° 13′ 54″	.997 846	.995 126	.073 630
12.8°	4° 15′ 54″	.997 812	.995 049	.074 206
12.9°	4° 17′ 54″	.997 777	.994 971	.074 781
13.0°	4° 19′ 53″	.997 743	.994 893	.075 357
13.1°	4° 21′ 53″	.997 708	.994 814	.075 932
13.2°	4° 23′ 53″	.997 673	.994 735	.076 508
13.3°	4° 25′ 53″	.997 638	.994 655	.077 083
13.4°	4° 27′ 53″	.997 602	.994 575	.077 658
13.5°	4° 29′ 53″	.997 566	.994 494	.078 233
13.6°	4° 31′ 53″	.997 530	.994 412	.078 808
13.7°	4° 33′ 52″	.997 493	.994 330	.079 383
13.8°	4° 35′ 52″	.997 457	.994 247	.079 957
13.9°	4° 37′ 52″	.997 420	.994 163	.080 532
14.0°	4° 39′ 52″	.997 383	.994 079	.081 106
14.1°	4° 41′ 52″	.997 345	.993 995	.081 681
14.2°	4° 43′ 51″	.997 307	.993 909	.082 255
14.3°	4° 45′ 51″	.997 269	.993 823	.082 829
14.4°	4° 47′ 51″	.997 231	.993 737	.083 403
14.5°	4° 49′ 51″	.997 192	.993 650	.083 977
14.6°	4° 51′ 51″	.997 154	.993 562	.084 551
14.7°	4° 53′ 51″	.997 115	.993 474	.085 125
14.8°	4° 55′ 50″	.997 075	.993 385	.085 699
14.9°	4° 57′ 50″	.997 036	.993 296	.086 272
15.0°	4° 59′ 50″	.996 996	.993 206	.086 846

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
15.0°	4° 59′ 50″	.996 990	.993 206	.086 846
15.1°	5° 01′ 50″	.996 956	.993 115	.087 419
15.2°	5° 03′ 50″	.996 915	.993 024	.087 992
15.3°	5° 05′ 49″	.996 874	.992 932	.088 565
15.4°	5° 07′ 49″	.996 833	.992 840	.089 138
15.5°	5° 09′ 49″	.996 792	.992.747	.089 711
15.6°	5° 11′ 49″	.996 751	.992 653	.090 284
15.7°	5° 13′ 49″	.996 709	.992 559	.090 857
15.8°	5° 15′ 48″	.996 667	.992 465	.091 429
15.9°	5° 17′ 48″	.996 625	.992 369	.092 001
16.0°	5° 19′ 48″	.996 582	.992 273	.092 574
16.1°	5° 21′ 48″	.996 539	.992 177	.093 146
16.2°	5° 23′ 47″	.996 496	.992 080	.093 718
16.3°	5° 25′ 47″	.996 453	.991 982	.094 290
16.4°	5° 27′ 47″	.996 409	.991 884	.094 862
16.5°	5° 29′ 47″	.996 366	.991 785	.095 433
16.6°	5° 31′ 46″	.996 321	.991 685	.096 005
16.7°	5° 33′ 46″	.996 277	.991 585	.096 576
16.8°	5° 35′ 46″	.996 232	.991 484	.097 148
16.9°	5° 37′ 46″	.996 187	.991 383	.097 719
17.0°	5° 39′ 45″	.996 142	.991 281	.098 290
17.1°	5° 41′ 45″	.996 097	.991 179	.098 861
17.2°	5° 43′ 45″	.996 051	.991 076	.099 432
17.3°	5° 45′ 45″	.996 005	.990 972	.100 002
17.4°	5° 47′ 44″	.995 959	.990 868	.100 573
17.5°	5° 49′ 44″	.995 912	.990 763	.101 143
17.6°	5° 51′ 44″	.995 865	.990 657	.101 713
17.7°	5° 53′ 44″	.995 818	.990 551	.102 284
17.8°	5° 55′ 43″	.995 771	.990 445	.102 854
17.9°	5° 57′ 43″	.995 723	.990 338	.103 424
18.0°	5° 59′ 43″	.995 676	.990 230	.103 993
18.1°	6° 01′ 42″	.995 627	.990 122	.104 563
18.2°	6° 03′ 42″	.995 579	.990 013	.105 132
18.3°	6° 05′ 42″	.995 530	.989 903	.105 702
18.4°	6° 07′ 42″	.995 482	.989 793	.106 271
18.5°	6° 09′ 41″	.995 432	.989 682	.106 840
18.6°	6° 11′ 41″	.995 383	.989 571	.107 409
18.7°	6° 13′ 41″	.995 333	.989 459	.107 978
18.8°	6° 15′ 40″	.995 283	.989 346	.108 547
18.9°	6° 17′ 40″	.995 233	.989 233	.109 115
19.0°	6° 19′ 40″	.995 183	.989 120	.109 683
19.1°	6° 21′ 39″	.995 132	.989 005	.110 252
19.2°	6° 23′ 39″	.995 081	.988 891	.110 820
19.3°	6° 25′ 39″	.995 029	.988 775	.111 388
19.4°	6° 27′ 38″	.994 978	.988 659	.111 956
19.5°	6° 29′ 38″	.994 926	.988 543	.112 523
19.6°	6° 31′ 38″	.994 874	.988 425	.113 091
19.7°	6° 33′ 37″	.994 822	.988 308	.113 658
19.8°	6° 35′ 37″	.994 769	.988 189	.114 226
19.9°	6° 37′ 37″	.994 716	.988 070	.114 793
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	$\frac{C}{L}$	$\frac{X}{L}$	$\frac{Y}{L}$
20.0°	6° 39′ 36″	.994 663	.987 951	.115 360
20.1°	6° 41′ 36″	.994 610	.987 830	.115 926
20.2°	6° 43′ 36″	.994 556	.987 710	.116 493
20.3°	6° 45′ 35″	.994 502	.987 589	.117 059
20.4°	6° 47′ 35″	.994 448	.987 467	.117 626
20.5°	6° 49′ 34″	.994 393	.987 344	.118 192
20.6°	6° 51′ 34″	.994 339	.987.221	.118 758
20.7°	6° 53′ 34″	.994 284	.987 097	.119 324
20.8°	6° 55′ 33″	.994 228	.986 973	.119 890
20.9°	6° 57′ 33″	.994 173	.986 849	.120 455
21.0°	6° 59′ 32″	.994 117	.986 723	.121 021
21.1°	7° 01′ 32″	.994 061	.986 597	.121 586
21.2°	7° 03′ 32″	.994 005	.986 471	.122 151
21.3°	7° 05′ 31″	.993 948	.986 343	.122 716
21.4°	7° 07′ 31″	.993 891	.986 216	.123 281
21.5°	7° 09′ 30″	.993 834	.986 088	.123 846
21.6°	7° 11′ 30″	.993 777	.985 959	.124 410
21.7°	7° 13′ 30″	.993 719	.985 829	.124 974
21.8°	7° 15′ 29″	.993 661	.985 699	.125 539
21.9°	7° 17′ 29″	.993 603	.985 568	.126 103
22.0°	7° 19′ 28″	.993 545	.985 437	.126 667
22.1°	7° 21′ 28″	.993 486	.985 305	.127 230
22.2°	7° 23′ 28″	.993 427	.985 173	.127 794
22.3°	7° 25′ 27″	.993 368	.985 040	.128 357
22.4°	7° 27′ 27″	.993 308	.984 906	.128 920
22.5°	7° 29′ 26″	.993 248	.984 772	.129 483
22.6°	7° 31′ 26″	.993 188	.984 638	.130 046
22.7°	7° 33′ 25″	.993 128	.984 502	.130 609
22.8°	7° 35′ 25″	.993 068	.984 366	.131 172
22.9°	7° 37′ 24″	.993 007	.984 230	.131 734
23.0°	7° 39′ 24″	.992 946	.984 093	.132 296
23.1°	7° 41′ 23″	.992 884	.983 955	.132 858
23.2°	7° 43′ 23″	.992 823	.983 817	.133 420
23.3°	7° 45′ 22″	.992 761	.983 678	.133 982
23.4°	7° 47′ 22″	.992 699	.983 539	.134 543
23.5°	7° 49′ 21″	.992 636	.983 399	.135 105
23.6°	7° 51′ 21″	.992 574	.983 258	.135 666
23.7°	7° 53′ 20″	.992 511	.983 117	.136 227
23.8°	7° 55′ 20″	.992 448	.982 976	.136 788
23.9°	7° 57′ 19″	.992 384	.982 834	.137 348
24.0°	7° 59′ 19″	.992 321	.982 691	.137 909
24.1°	7° 01′ 18″	.992 257	.982 547	.138 469
24.2°	8° 03′ 18″	.992 192	.982 403	.139 029
24.3°	8° 05′ 17″	.992 128	.982 259	.139 589
24.4°	8° 07′ 17″	.992 063	.982 114	.140 149
24.5°	8° 09′ 16″	.991 998	.981 968	.140 708
24.6°	8° 11′ 16″	.991 933	.981 822	.141 268
24.7°	8° 13′ 15″	.991 867	.981 675	.141 827
24.8°	8° 15′ 15″	.991 801	.981 528	.142 386
24.9°	8° 17′ 14″	.991 735	.981 380	.142 945
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
25.0°	8° 19′ 14″	.991 669	.981 231	.143 504
25.1°	8° 21′ 13″	.991 602	.981 082	.144 062
25.2°	8° 23′ 12″	.991 536	.980 932	.144 620
25.3°	8° 25′ 12″	.991 468	.980 782	.145 179
25.4°	8° 27′ 11″	.991 401	.980 631	.145 737
25.5°	8° 29′ 11″	.991 333	.980 479	.146 294
25.6°	8° 31′ 10″	.991 265	.980 327	.146 852
25.7°	8° 33′ 10″	.991 197	.980 175	.147 409
25.8°	8° 35′ 09″	.991 129	.980 022	.147 966
25.9°	8° 37′ 08″	.991 060	.979 868	.148 523
26.0°	8° 39′ 08″	.990 991	.979 714	.149 080
26.1°	8° 41′ 07″	.990 922	.979 559	.149 637
26.2°	8° 43′ 07″	.990 853	.979 403	.150 193
26.3°	8° 45′ 06″	.990 783	.979 247	.150 750
26.4°	8° 47′ 05″	.990 713	.979 090	.151 306
26.5°	8° 49′ 05″	.990 642	.978 933	.151 861
26.6°	8° 51′ 04″	.990 572	.978 776	.152 417
26.7°	8° 53′ 03″	.990 501	.978 617	.152 973
26.8°	8° 55′ 03″	.990 430	.978 459	.153 528
26.9°	8° 57′ 02″	.990 359	.978 299	.154 083
27.0°	8° 59′ 02″	.990 287	.978 139	.154 638
27.1°	9° 01′ 01″	.990 215	.977 978	.155 193
27.2°	9° 03′ 00″	.990 143	.977 817	.155 747
27.3°	9° 05′ 00″	.990 071	.977 655	.156 301
27.4°	9° 06′ 59″	.989 998	.977 493	.156 855
27.5°	9° 08′ 58″	.989 925	.977 330	.157 409
27.6°	9° 10′ 58″	.989 852	.977 167	.157 963
27.7°	9° 12′ 57″	.989 779	.977 003	.158 516
27.8°	9° 14′ 56″	.989 705	.976 838	.159 070
27.9°	9° 16′ 55″	.989 631	.976 673	.159 623
28.0°	9° 18′ 55″	.989 557	.976 508	.160 176
28.1°	9° 20′ 54″	.989 482	.976 341	.160 728
28.2°	9° 22′ 53″	.989 408	.976 174	.161 281
28.3°	9° 24′ 53″	.989 333	.976 007	.161 833
28.4°	9° 26′ 52″	.989 257	.975 839	.162 385
28.5°	9° 28′ 51″	.989 182	.975 670	.162 937
28.6°	9° 30′ 51″	.989 106	.975 500	.163 489
28.7°	9° 32′ 50″	.989 030	.975.331	.164 040
28.8°	9° 34′ 49″	.988 954	.975 161	.164 591
28.9°	9° 36′ 48″	.988 877	.974 990	.165 142
29.0°	9° 38′ 48″	.988 800	.974 819	.165 693
29.1°	9° 40′ 47″	.988 723	.974 647	.166 244
29.2°	9° 42′ 46″	.988 646	.974 475	.166 794
29.3°	9° 44′ 45″	.988 568	.974 301	.167 344
29.4°	9° 46′ 45″	.988 491	.974 128	.167 894
29.5°	9° 48′ 44″	.988 412	.973 954	.168 444
29.6°	9° 50′ 43″	.988 334	.973 779	.168 993
29.7°	9° 52′ 42″	.988 255	.973 604	.169 543
29.8°	9° 54′ 41″	.988 176	.973 428	.170 092
29.9°	9° 56′ 41″	.988 097	.973 251	.170 641
30.0°	9° 58′ 40″	.988 018	.973 074	.171 189

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
30.0°	9° 58′ 40″	.988 018	.973 074	.171 189
30.1°	10° 00′ 39″	.987 938	.972 897	.171 738
30.2°	10° 02′ 38″	.987 858	.972 719	.172 286
30.3°	10° 04′ 37″	.987 778	.972 540	.172 834
30.4°	10° 06′ 37″	.987 698	.972 361	.173 382
30.5°	10° 08′ 36″	.987 617	.972 181	.173 929
30.6°	10° 10′ 35″	.987 536	.972 000	.174 477
30.7°	10° 12′ 34″	.987 455	.971 820	.175 023
30.8°	10° 14′ 33″	.987 373	.971 638	.175 571
30.9°	10° 16′ 32″	.987 291	.971 456	.176 117
31.0°	10° 18′ 32″	.987 209	.971 273	.176 664
31.1°	10° 20′ 31″	.987 127	.971 090	.177 210
31.2°	10° 22′ 30″	.987 044	.970 907	.177 756
31.3°	10° 24′ 29″	.986 962	.970 722	.178 302
31.4°	10° 26′ 28″	.986 879	.970 537	.178 847
31.5°	10° 28′ 27″	.986 795	.970 352	.179 392
31.6°	10° 30′ 26″	.986 712	.970 166	.179 938
31.7°	10° 32′ 25″	.986 628	.969 980	.180 482
31.8°	10° 34′ 24″	.986 544	.969 792	.181 027
31.9°	10° 36′ 24″	.986 459	.969 605	.181 571
32.0°	10° 38′ 23″	.986 375	.969 417	.182 116
32.1°	10° 40′ 22″	.986 290	.969 228	.182 659
32.2°	10° 42′ 21″	.986 205	.969 039	.183 203
32.3°	10° 44′ 20″	.986 119	.968 849	.183 747
32.4°	10° 46′ 19″	.986 033	.968 658	.184 290
32.5°	10° 48′ 18″	.985 948	.968 468	.184 833
32.6°	10° 50′ 17″	.985 861	.968 276	.185 376
32.7°	10° 52′ 16″	.985 775	.968 084	.185 918
32.8°	10° 54′ 15″	.985 688	.967 891	.186 460
32.9°	10° 56′ 14″	.985 601	.967 698	.187 002
33.0°	10° 58′ 13″	.985 514	.967 504	.187 544
33.1°	11° 00′ 12″	.985 426	.967 310	.188 086
33.2°	11° 02′ 11″	.985 339	.967 115	.188 627
33.3°	11° 04′ 10″	.985 251	.966 920	.189 168
33.4°	11° 06′ 09″	.985 162	.966 724	.189 709
33.5°	11° 08′ 08″	.985 074	.966 528	.190 250
33.6°	11° 10′ 07″	.984 985	.966 331	.190 790
33.7°	11° 12′ 06″	.984 896	.966 133	.191 330
33.8°	11° 14′ 05″	.984 807	.965 935	.191 870
33.9°	11° 16′ 04″	.984 717	.965 736	.192 410
34.0°	11° 18′ 03″	.984 627	.965 537	.192 949
34.1°	11° 20′ 02″	.984 537	.965 337	.193 488
34.2°	11° 22′ 01″	.984 447	.965 137	.194 027
34.3°	11° 24′ 00″	.984 356	.964 936	.194 566
34.4°	11° 25′ 59″	.984 265	.964 734	.195 104
34.5°	11° 27′ 58″	.984 174	.964 532	.195 643
34.6°	11° 29′ 57″	.984 083	.964 330	.196 180
34.7°	11° 31′ 56″	.983 991	.964 127	.196 718
34.8°	11° 33′ 55″	.983 899	.963 923	.197 256
34.9°	11° 35′ 54″	.983 807	.963 719	.197 793
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
35.0°	11° 37′ 53″	.983 715	.963 515	.198 330
35.1°	11° 39′ 52″	.983 622	.963 309	.198 866
35.2°	11° 41′ 50″	.983 529	.963 103	.199 403
35.3°	11° 43′ 49″	.983 436	.962 897	.199 939
35.4°	11° 45′ 48″	.983 343	.962 690	.200 475
35.5°	11° 47′ 47″	.983 249	.962 483	.201 010
35.6°	11° 49′ 46″	.983 155	.962 275	.201 546
35.7°	11° 51′ 45″	.983 061	.962 066	.202 081
35.8°	11° 53′ 44″	.982 966	.961 857	.202 616
35.9°	11° 55′ 43″	.982 872	.961 648	.203 151
36.0°	11° 57′ 41″	.982 777	.961 438	.203 685
36.1°	11° 59′ 40″	.982 681	.961 227	.204 219
36.2°	12° 01′ 39″	.982 586	.961 016	.204 753
36.3°	12° 03′ 38″	.982 490	.960 804	.205 286
36.4°	12° 05′ 37″	.982 394	.960 592	.205 820
36.5°	12° 07′ 36″	.982 298	.960 379	.206 353
36.6°	12° 09′ 34″	.982 201	.960 165	.206 886
36.7°	12° 11′ 33″	.982 104	.959 951	.207 418
36.8°	12° 13′ 32″	.982 007	.959 737	.207 951
36.9°	12° 15′ 31″	.981 910	.959 522	.208 483
37.0°	12° 17′ 30″	.981 813	.959 306	.209 014
37.1°	12° 19′ 28″	.981 715	.959 090	.209 546
37.2°	12° 21′ 27″	.981 617	.958 874	.210 077
37.3°	12° 23′ 26″	.981 518	.958 657	.210 608
37.4°	12° 25′ 25″	.981 420	.958 439	.211 139
37.5°	12° 27′ 23″	.981 321	.958 221	.211 669
37.6°	12° 29′ 22″	.981 222	.958 002	.212 199
37.7°	12° 31′ 21″	.981 122	.957 783	.212 729
37.8°	12° 33′ 20″	.981 023	.957 563	.213 259
37.9°	12° 35′ 18″	.980 923	.957 342	.213 788
38.0°	12° 37′ 17″	.980 823	.957 121	.214 317
38.1°	12° 39′ 16″	.980 722	.956 900	.214 846
38.2°	12° 41′ 14″	.980 622	.956 678	.215 375
38.3°	12° 43′ 13″	.980 521	.956 456	.215 903
38.4°	12° 45′ 12″	.980 420	.956 232	.216 431
38.5°	12° 47′ 11″	.980 318	.956 009	.216 959
38.6°	12° 49′ 09″	.980 217	.955 785	.217 486
38.7°	12° 51′ 08″	.980 115	.955 560	.218 013
38.8°	12° 53′ 07″	.980 012	.955 335	.218 540
38.9°	12° 55′ 05″	.979 910	.955 109	.219 067
39.0°	12° 57′ 04″	.979 807	.954 883	.219 593
39.1°	12° 59′ 02″	.979 704	.954 656	.220 119
39.2°	13° 01′ 01″	.979 601	.954 429	.220 645
39.3°	13° 03′ 00″	.979 498	.954 201	.221 171
39.4°	13° 04′ 58″	.979 394	.953 973	.221 696
39.5°	13° 06′ 57″	.979 290	.953 744	.222 221
39.6°	13° 08′ 56″	.979 186	.953 514	.222 745
39.7°	13° 10′ 54″	.979 081	.953 284	.223 270
39.8°	13° 12′ 53″	.978 977	.953 054	.223 794
39.9°	13° 14′ 51″	.978 872	.952 823	.224 318
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	A	C/L	X/L	Y/L
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841
40.1°	13° 18′ 48″	.978 661	.952 359	.225 365
40.2°	13° 20′ 47″	.978 555	.952 127	.225 888
40.3°	13° 22′ 46″	.978 449	.951 893	.226 410
40.4°	13° 24′ 44″	.978 343	.951 660	.226 933
40.5°	13° 26′ 43″	.978 236	.951 426	.227 455
40.6°	13° 28′ 41″	.978 130	.951 191	.227 977
40.7°	13° 30′ 40″	.978 023	.950 956	.228 498
40.8°	13° 32′ 38″	.977 915	.950 720	.229 019
40.9°	13° 34′ 37″	.977 808	.950 484	.229 540
41.0°	13° 36′ 35″	.977 700	.950 247	.230 061
41.1°	13° 38′ 34″	.977 592	.950 010	.230 581
41.2°	13° 40′ 32″	.977 484	.949 772	.231 102
41.3°	13° 42′ 31″	.977 375	.949 533	.231 621
41.4°	13° 44′ 29″	.977 266	.949 294	.232 141
41.5°	13° 46′ 28″	.977 157	.949 055	.232 660
41.6°	13° 48′ 26″	.977 048	.948 815	.233 179
41.7°	13° 50′ 25″	.976 938	.948 575	.233 698
41.8°	13° 52′ 23″	.976 828	.948 334	.234 216
41.9°	13° 54′ 22″	.976 718	.948 092	.234 734
42.0°	13° 56′ 20″	.976 608	.947 850	.235 252
42.1°	13° 58′ 18″	.976 498	.947 608	.235 769
42.2°	14° 00′ 17″	.976 387	.947 365	.236 286
42.3°	14° 02′ 15″	.976 276	.947 121	.236 803
42.4°	14° 04′ 14″	.976 164	.946 877	.237 320
42.5°	14° 06′ 12″	.976 053	.946 632	.237 836
42.6°	14° 08′ 10″	.975 941	.946 387	.238 352
42.7°	14° 10′ 09″	.975 829	.946 142	.238 868
42.8°	14° 12′ 07″	.975 716	.945 895	.239 383
42.9°	14° 14′ 06″	.975 604	.945 649	.239 898
43.0°	14° 16′ 04″	.975 491	.945 402	.240 413
43.1°	14° 18′ 02″	.975 378	.945 154	.240 927
43.2°	14° 20′ 01″	.975 264	.944 906	.241 442
43.3°	14° 21′ 59″	.975 151	.944 657	.241 956
43.4°	14° 23′ 57″	.975 037	.944 408	.242 469
43.5°	14° 25′ 56″	.974 923	.944 158	.242 982
43.6°	14° 27′ 54″	.974 808	.943 908	.243 495
43.7°	14° 29′ 52″	.974 694	.943 657	.244 008
43.8°	14° 31′ 50″	.974 579	.943 405	.244 520
43.9°	14° 33′ 49″	.974 464	.943 154	.245 032
44.0°	14° 35′ 47″	.974 348	.942 901	.245 544
44.1°	14° 37′ 45″	.974 233	.942 648	.246 055
44.2°	14° 39′ 44″	.974 117	.942 395	.246 567
44.3°	14° 41′ 42″	.974 001	.942 141	.247 077
44.4°	14° 43′ 40″	.973 884	.941 887	.247 588
44.5°	14° 45′ 38″	.973 768	.941 632	.248 098
44.6°	14° 47′ 37″	.973 651	.941 377	.248 608
44.7°	14° 49′ 35″	.973 534	.941 121	.249 117
44.8°	14° 51′ 33″	.973 416	.940 864	.249 627
44.9°	14° 53′ 31″	.973 299	.940 608	.250 135
45.0°	14° 55′ 29″	.973 181	.940 350	.250 644

TABLE OF FUNCTIONS OF THE TEN-CHORD SPIRAL.—Cont'd.

Δ	U/L	V/L	Δ	U/L	V/L
0°	.666 667	.333 333	23°	.672 422	.338 586
1°	.666 678	.333 343	24°	.672 943	.339 061
2°	.666 710	.333 372	25°	.673 486	.339 559
3°	.666 763	.333 421	26°	.674 054	.340 078
4°	.666 838	.333 490	27°	.674 645	.340 619
5°	.666 935	.333 578	28°	.675 261	.341 183
6°	.667 053	.333 685	29°	.675 901	.341 769
7°	.667 193	.333 812	30°	.676 566	.342 378
8°	.667 354	.333 959	31°	.677 256	.343 011
9°	.667 537	.334 126	32°	.677 971	.343 667
10°	.667 742	.334 313	33°	.678 712	.344 346
11°	.667 968	.334 519	34°	.679 478	.345 050
12°	.668 216	.334 746	35°	.680 270	.345 777
13°	.668 487	.334 992	36°	.681 089	.346 529
14°	.668 779	.335 259	37°	.681 935	.347 307
15°	.669 094	.335 546	38°	.682 808	.348 109
16°	.669 431	.335 853	39°	.683 708	.348 937
17°	.669 790	.336 181	40°	.684 636	.349 791
18°	.670 172	.336 529	41°	.685 592	.350 671
19°	.670 576	.336 899	42°	.686 577	.351 578
20°	.671 003	.337 289	43°	.687 590	.352 513
21°	.671 453	.337 700	44°	.688 633	.353 474
22°	.671 926	.338 132	45°	.689 706	.354 464

Appendix B.

SELECTION OF LENGTH OF TRANSITION SPIRAL.

By Frank H. Carter, Assoc. Mem. Am. Soc. C. E.

In fixing the alinement of a projected fast interurban electric railway recently, the writer was confronted with a dearth of information concerning either theory or practice for rigorously selecting proper lengths of easement or transition curves. The only line of thought or suggestion on the subject which could be found was that outlined by Prof. Talbot in his work on the transition curve, and that appeared to be more or less specially applicable to his particular spiral. Because of the fact that standard spirals of the Searles type had been adopted and were in use on the road in question, it seemed inadvisable to make any radical change in the type of easement curve. None of these standard easement curves, however, were of a length greater than 100 ft., while the theory which is presented herewith demands lengths up to and in some cases exceeding 300 ft.

The old spirals having chord lengths of 10 ft. were adopted as "base tables," and new easement curves were developed from these by merely increasing the chord lengths to 20, 30, 40 and 50 ft., maintaining the same central angles with, of course, the same "angle of increment," which term will be readily understood by those familiar with the Searles spiral. For the benefit of those not familiar with this type, the Searles spiral may be defined as a compound curve with successive equal chord lengths subtended by 2, 3, 4, 5, etc., times the angle subtended by the first chord length, which latter, of course, may then be defined as the "angle of increment."

The determination of the proper length of transition, however, was as far from a reasonable solution as ever. Further search was then made of printed information on the subject, and a practically complete bibliography of existing English literature on the proper lengths of transition curves and rate of rise of superelevation of outer rail was compiled together with brief synopses of the main features in each article.

Almost on the day of the completion of this compilation, and while the writer was engaged in an attempt at a rigorous solution of the problem, with practically his only suggestion a mass of "rules of thumb" or tracklayer's experience, there appeared a very creditable report of the Committee on Track of the American Railway Engineering and Maintenance of Way Association and published in Bulletin 108 of that body. This report is replete with compiled information, some, it is true, of the "rule of thumb" order, but with a principle, new to the writer, from several of the roads, namely, a length of curve dependent upon the rate of rise of the outside of a train on a curve (at the rail) in inches per second. There were letters from two roads with diagrams from one, both very suggestive of a method of attacking the problem, namely, Cleveland, Cincinnati, Chicago & St. Louis Railway and the Pittsburg & Lake Erie Railroad.

With this new material, it proved to be an easy matter to establish a relation between superelevation of outer rail, radius of the central curve, speed of the train, rate of rise of train on outer rail in inches per second, and the proper length of transition curve, on a scientific basis. The result of these computations and a brief discussion of the basic principles involved, with reasons for their adoption, are presented as follows:

The rate of rise of superelevation on easement curves is largely, if not entirely, a question of its effect on passengers as to whether the rapidity of vertical rise of one side of the train produces a disagreeable sensation. An attempt to formulate the proper length of transition curve from the rate of rise of rail in inches per 100 ft., without regard to the speed of the train, is approaching the problem from the wrong standpoint. In any formula of type $I = C D V^2$ the constant C, as will be shown, fixes the rate of rise of superelevation of rail; therefore, but one curve and one speed will satisfy this equation in regard to rapidity of rise of train in inches per second. All other curves or speeds will convey different sensations of ease of riding to the passenger. The average rate of rise of the outside of the train (at the rail) in inches per second should be the governing function for the determination of the length of transition curve, as will be discussed a little later. In fixing alinement, smoothness of riding is all important for comfort; hence, the same rate of rise of superelevation on curves in inches per second should govern for the entire road, where a schedule can be predicted with any degree of certainty, a difficult matter, of course, in most cases for new roads, but almost always capable of realization in realinement, when timetables are established.

It appears to the writer that the clause for insertion in the Manual of the American Railway Engineering and Maintenance of Way Association, viz.: "that the length of the curve should not be less than thirty times the elevation in inches for the ultimate speed" (literally meaning that no rise of superelevation shall be greater than 1 in. in 30 ft.) is a wise provision for places where the speed cannot be predicted, but that is not the best practice, in that the rate of rise of transition will not in that case depend upon the speed of the train.

The last clause of the paragraph for the Manual of Recommended Practice of the American Railway Engineering and Maintenance of Way Association, concerning the length of easement curve, viz.: "that the curve should not be less than two-thirds the ultimate speed in miles per hour times the elevation in inches," places a more rapid rate of rise of the car in inches per second than has been considered best practice for steam roads, according to available information in the hands of the writer. By this rule the rate of rise would amount to about 2.17 in. per second, while the common practice appears to be from 1¼ to 1½ in. per second rise.

The length of easement curves used on the Cleveland, Cincinnati, Chicago & St. Louis Railway is apparently based on an assumed rate of rise of 1¼ in. per second, and the practice of the Delaware, Lackawanna & Western Railroad is given as 1½ in. per second.

It is true that cases may be cited where faster rates of rise have been used; notably, a local fast urban electric railway has several spirals where the rate of rise is one inch in 20 ft., corresponding to 2.20 in. per second vertical rise at 30 miles per hour.

These curves are said to be easy riding curves from the standpoint of electric road practice, but jolts and roughness of riding which might be tolerated by passengers on an urban electric road or an elevated road, would not be considered good practice for steam roads, where the demand is for smooth riding, such, for instance, that passengers might be able to write a letter comfortably while on a car in motion. It may be of interest to note at this point that this same railway has lately made radical changes in increasing its length of transition curve.

To formulate the foregoing discussion, let

$e =$ the superelevation in feet
$g =$ distance in feet between centers of rail heads
$V =$ speed of train in miles per hour
$v =$ speed of train in feet per second
$R =$ radius of central curve in feet
$D =$ degree of curve
$L =$ length of transition curve in feet
$l =$ distance in feet transition curve superelevation 1 in.
$a =$ inches per second a train is assumed to rise vertically on transition

$e = .06688\, g \frac{V^2}{R}$ from the well-known formula for superelevation of the outer rail on curves

but $\frac{L}{l} = 12\, e$; $\frac{1}{l} = \frac{12\, e}{L} = .06688 \frac{g\, V^2}{L\, R}\, 12$

assuming $g = 4.92$

$$\frac{1}{l} = 3.94 \frac{V^2}{L\, R} (2) \text{ or } l = \frac{L\, R}{V^2}\, 0.254$$

whence $$L = 3.94 \frac{V^2}{R}\, l \quad (3)$$

by definition $a = \frac{v}{l}$; simplifying $a = \frac{v}{l} = \frac{V\left(\frac{5280}{3600}\right)}{l}$; $l = 1.468 \frac{V}{a}$ (4) by (2)

$l = 0.254 \frac{L\, R}{V^2}$ and by (4) $l = 1.468 \frac{V}{a}$.

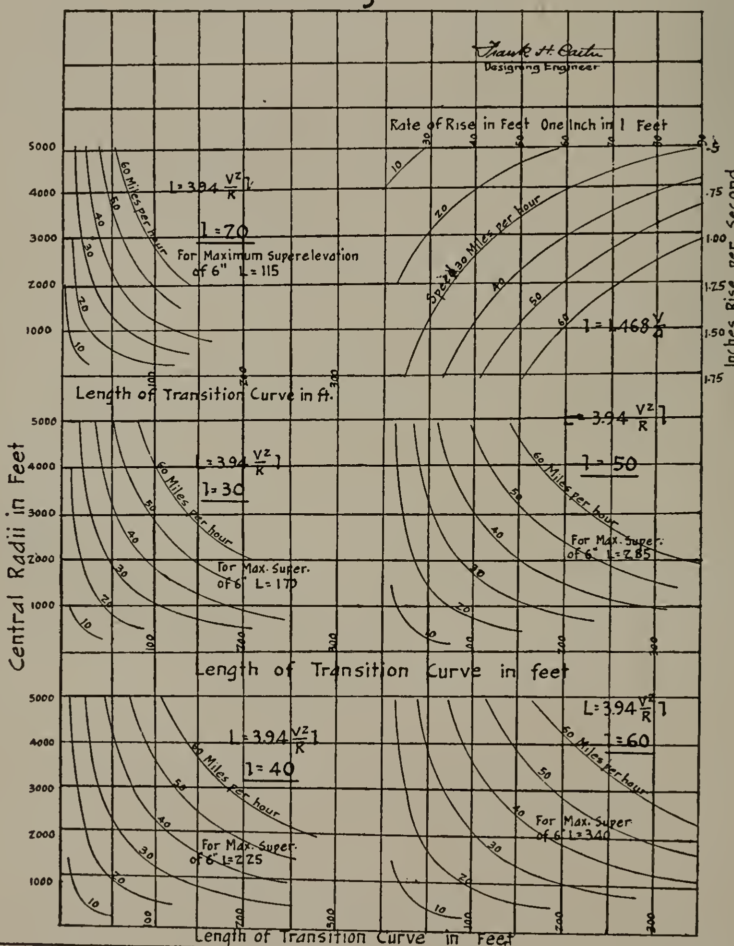
equating equals $0.254 \frac{L\, R}{V^2} = 1.468 \frac{V}{a}$.

$$L = 5.78\left(\frac{V^3}{aR}\right) \quad (5) \qquad L = 0.00101\left(\frac{V^3 D}{a}\right) \quad (6).$$

The accompanying diagram illustrates graphically the relations of the various functions to each other. With these diagrams a comparative study may be made of the practice of some of the companies given in Bulletin 108, previously referred to, and other information gathered elsewhere, by assembling the data on a common basis.

Fig. 1 gives graphically solutions of formula (3) for various rates of rise of superelevation from 1 in. in 20 ft. to 1 in. in 60 ft.; also a graphical solution of formula (4). A study of this diagram will reveal the

Fig. 1



relations between rise of superelevation of the rail and the rise of the outside wheel of a train in inches per second passing over a given curve at a given speed with given rates of rise of superelevation.

Fig. 2 shows graphically the two rules for minimum length of easement curve as proposed for the Manual of Recommended Practice of the American Railway Engineering and Maintenance of Way Association.

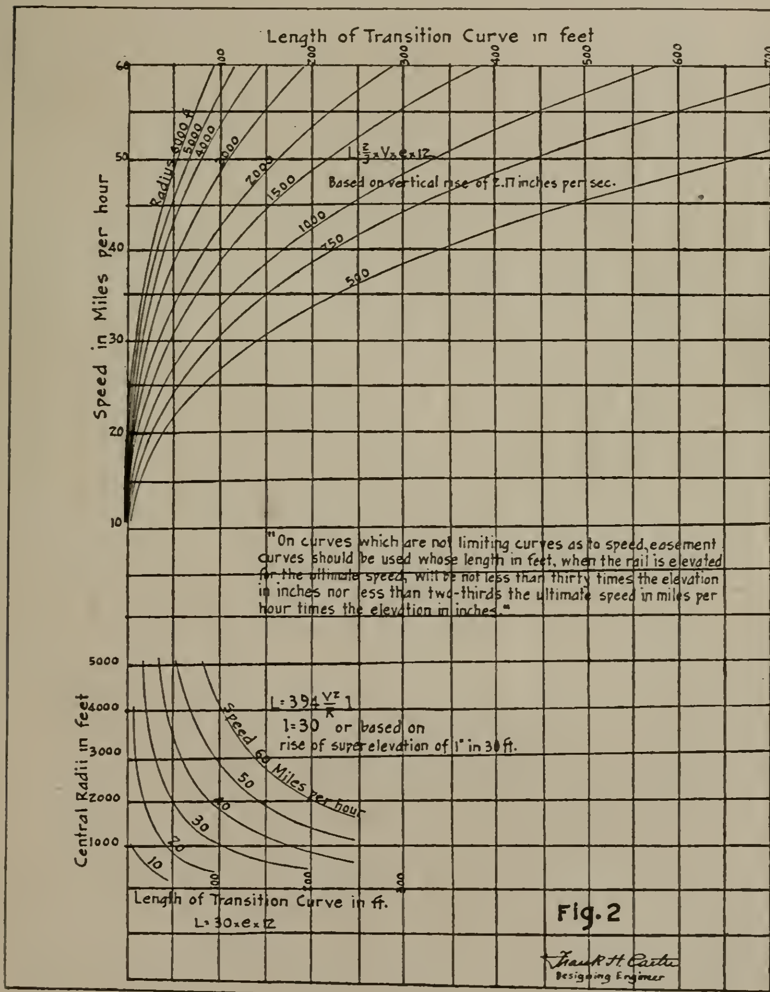


Fig. 3 gives the complete solution graphically of equation (3) for the required determination of the length of easement curve with any assumed rate of rise of train in inches per second, giving at the same time

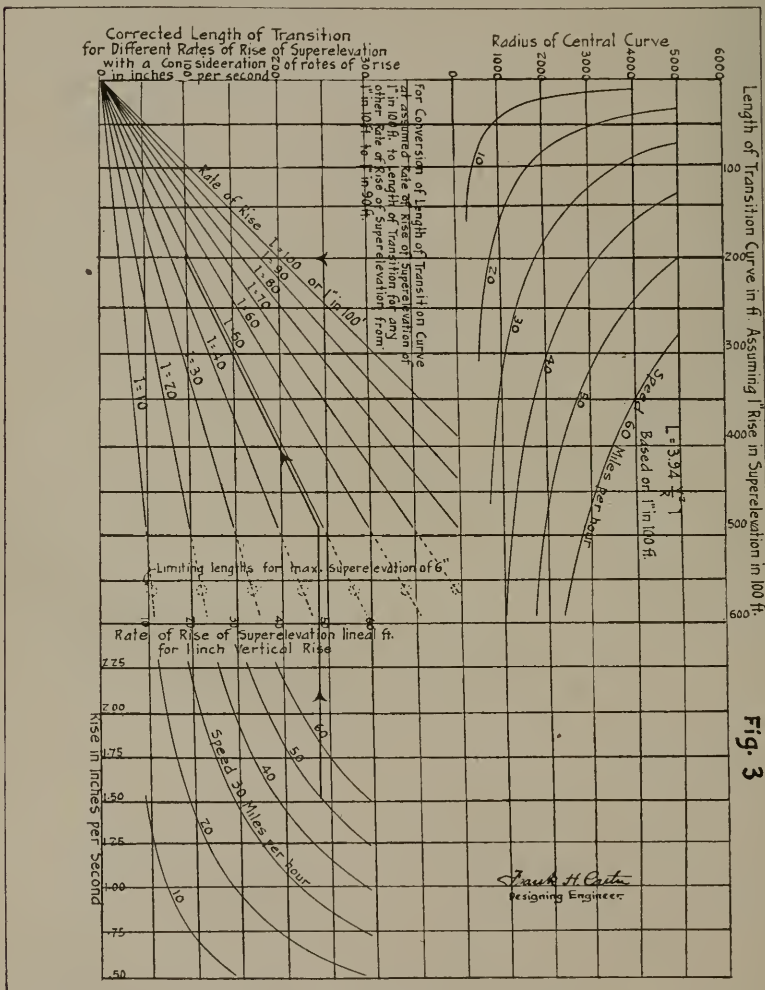


Fig. 3

the rate of rise of superelevation, which latter varies with the square of the speed. (The rate of rise in inches per second should be fixed for the entire length of the road.)

Fig. 4 gives graphically the solution of equation (5). By means of the auxiliary diagram the relation between the rate of rise of superelevation of the transition and the rate of rise of train in inches per second may be read.

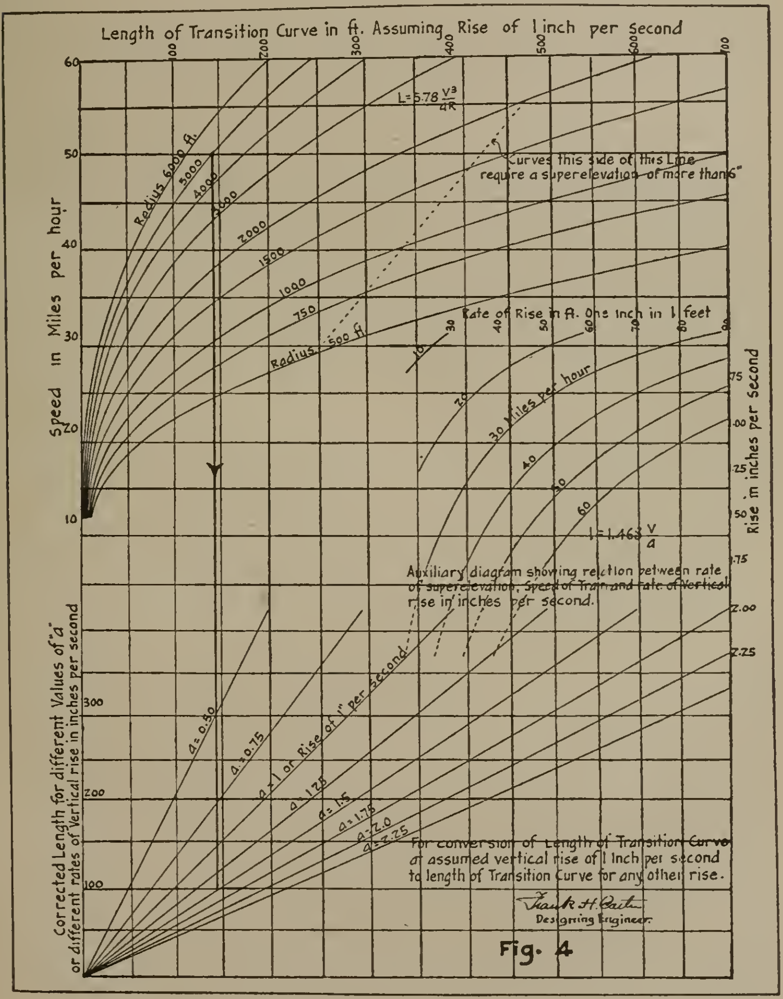


Fig. 4

Example: Find the length of transition and rate of rise of superelevation for

R = 5,000 ft.
V = 50 m. p. h.
a = 1.50 inches per second.

By Fig. 4, $L = 145$, assuming 1 in. per second; following the line $L = 145$ to the diagonal $a = 1.50$ in. per sec., $L = 98$ ft., and by use of the auxiliary diagram, $l = 49$ ft.

The same problem may be solved by diagram (3), $L = 200$ ft., assuming a rise of superelevation of 1 in. in 100 ft., and from the diagram on the relation between the rate of rise of superelevation and the rate of rise of train in inches per second, l is found to be 49 ft. as before, whence $L = 98$ ft.

Fig. 4 is simpler than (3) and the problem may be solved more quickly, also without reference to the rate of rise in feet of length per 1 ft. vertical rise.

The writer, in closing, again wishes to emphasize his indebtedness to the Committee's report, also to the letters accompanying the report of the Committee on Track in Bulletin 108 of the Proceedings of the American Railway Engineering and Maintenance of Way Association, particularly those of Messrs. Edwin F. Wendt, Assistant Engineer, Pittsburg & Lake Erie Railroad, and Robert Ferriday, Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway.

DISCUSSION.

(Vice-President Cushing in the chair.)

Vice-President Cushing:—We will now take up the report of the Committee on Track. Mr. C. E. Knickerbocker, Chairman, will present the report.

Mr. C. E. Knickerbocker (New York, Ontario & Western):—In making up the report of this year we tried to carry out as closely as we could the requirements of the Board of Direction, and in doing that they asked us to refer to the revision of the Manual. This we have done in a general way, going over what we have found in previous Manuals, and you will find a recommendation as to the revision of the Manual in the report. The first conclusion is that the changes in the Manual as proposed be adopted.

Vice-President Cushing:—The conclusions of the Committee are found on page 18 of the Bulletin, and the Secretary will read the first one.

The Secretary:—"Conclusion (1): That the changes in the Manual, as proposed, be adopted."

Mr. Knickerbocker:—The change recommended are those words which appear in italics: "For minor curves, an increase in length of about 50 per cent. over the minimum is recommended when such increase will not seriously affect the cost or adversely affect the degree of curve." This change came about after the Sub-Committee on Spirals had practically completed a very extensive report, which work has been going on for five or six years, and at the request of that Committee, and upon the recommendation of practically all of the Committee, it was found necessary to make this addition, and that is why we thought it would be best for us to do it, and that is why we ask for that change.

Prof. A. N. Talbot (University of Illinois):—May I inquire whether this minimum length brings up action on the diagram which is given later in the report, or whether we shall have a chance to discuss that further on?

Mr. Knickerbocker:—That will come up under the regular conclusion, No. 7, that the report on spirals be adopted.

Mr. C. E. Lindsay (New York Central & Hudson River):—I move that we postpone action on the conclusion now under consideration until conclusion No. 7 has been passed on.

(The motion carried.)

Mr. Knickerbocker:—The minimum length was passed on two years ago. We presented a diagram showing it, but the length has already been adopted by the Association. We make it a part of the illustrations to take care of what has already been passed, which we were not able to give at that time.

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis):—I would like to suggest that the Secretary read that portion of the Manual that this refers to. I think that would clear the case up. It is my understanding that these words in italics take some restrictions from the previous recommendation.

Mr. J. B. Jenkins (Baltimore & Ohio) :—The convention two years ago adopted rules for the minimum length of spiral, but made no recommendation as to spirals longer than the minimum; these words in italics merely recommend a longer spiral for use when it is convenient and does not adversely affect the degree of curve or seriously affect the cost of the work.

Vice-President Cushing:—Is that explanation sufficient?

Mr. Lindsay:—This is a question related closely to the spiral, and I see no harm in laying the conclusion on the table and considering it when we reach the consideration of the spiral.

Vice-President Cushing:—It hardly seems necessary to put it to a vote. The Committee will let that rest until it passes the two other conclusions.

The Secretary:—"Conclusion (2) That the title of the specifications for spring and rigid frogs adopted by the convention of 1910 be changed to read: 'General Specifications for Frogs, Crossings and Switches.'"

Vice-President Cushing:—Any discussion on conclusion 2? I understand this to be simply a change in title of the former article as adopted on that subject. What was the former heading?

Mr. Knickerbocker:—Specifications which were passed last year and which are given in Bulletin 119, on page 177, state: "Specifications for Spring and Rigid Frogs," but do not take in the switches or the crossings, and at the request of the Board of Direction we have prepared specifications for crossings, as well as switches, and to simplify the whole specification we would like to put that under one heading so that we can get the thing started, and the details will follow later.

Vice-President Cushing:—Any discussion on conclusion 2? If not, it will be approved.

The Secretary:—"Conclusion (3): That the 'General Instructions for Ordering or Contracting for Frogs, Crossings and Switches,' as given in the report, shall be prefixed to the specifications mentioned above."

Vice-President Cushing:—Will the Chairman of the Committee explain conclusion 3?

Mr. Knickerbocker:—In the previous report which was adopted, the details were found not to be quite sufficient upon which to place an order for frogs or crossings or switches, without giving additional information, and these specifications could not be added to, unless we added something to say what they should do, and what they should not do; we have just added that which will come up in discussion on the specification on switches.

Mr. Lindsay:—Would it not be in order to take up seriatim the general instructions for ordering or contracting for frogs, crossings and switches?

Vice-President Cushing:—That will now be done.

The Secretary:—"Manufacturers shall submit for approval detail shop drawings showing construction and dimensions of all parts to be furnished in accordance with these specifications. The drawings shall be on sheets twenty-two (22) in. wide, with a border line one-half (½) in. from the top, bottom and right-hand edge, and one and one-half (1½) in. from the left-hand edge. The standard length of drawings shall be thirty (30) in., except that, when necessary, longer sheets may be used and folded back to the standard length.

"Drawings of one subject only shall appear on a sheet.

"Scale of general drawings shall be 1½ in. = 1 ft., details not less than 3 in. = 1 ft. Conventional shading shall be used in sectional drawings. All dimensions and distances shall be shown plainly in figures.

"The title shall be placed in the lower right-hand corner.

"All drawings are intended to form a part of the specifications. Anything which is not shown on the drawings but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either, but which is reasonably implied, shall be furnished the same as if specifically shown and mentioned in both. Should anything be omitted from the drawings or specifications which is necessary for a clear understanding of the work, or should any error appear in either the drawings or specifications affecting the work, it shall be the duty of the manufacturer to notify the company and he shall not proceed with the work until instructed to do so by the company."

Mr. Lindsay:—May not the words "are intended to" in the beginning of the fifth paragraph be omitted?

Vice-President Cushing:—The Committee says it will omit the word "intended."

Mr. G. H. Tinker (New York, Chicago & St. Louis):—It does not seem to me that the first and last paragraphs are quite consistent. The last paragraph states that all drawings are to be a part of the specifications. The first paragraph says the manufacturer shall make the drawings. If the railroad company makes the drawings they should be a part of the specifications. It seems to me that that is the proper procedure in any case. I ask if it is good practice to require the manufacturers to make plans of the crossings. The road with which I am connected makes its own plans, submits them to the manufacturers, and the manufacturers proceed according to the plans; in that case the plans are a part of the specifications.

Mr. Knickerbocker:—A great many railroads cannot afford to make the plans, and those railroads ask the manufacturers to submit plans for certain crossings, and they do it. Many railroads do not have the opportunity to make these plans, and sometimes they are in a hurry for the crossing and cannot wait to make the plans, and they ask the manufacturers who make the crossings to submit a plan with a proposal for furnishing the crossing, and it is a quick way to obtain a crossing, which you cannot get in any other way.

Mr. J. P. Snow (Boston & Maine):—There is a distinction between the first and last paragraphs. The first paragraph recites that the manufacturer shall make his own drawings; this is right, because perhaps his shop nomenclature differs from the practice of others, and for this reason he is called upon to make detailed shop drawings. The last paragraph refers to drawings made by the railroad company, which may be nothing but line drawings showing the layout of the crossing.

The Secretary:—"1. Lengths, 11 ft., 16 ft. 6 in., 22 ft. or 33 ft."

Mr. Knickerbocker:—The length of switches was agreed to in the report last year, and we submitted a table which shows the length of the leads and the details, and we took for our basis the four lengths of switches which were adopted by the convention of last year, and which we understood were finally accepted as the four lengths to which we would work, and we have tried to follow that out in this report.

Vice-President Cushing:—It is not the intention to re-open this question, as there is nothing to discuss.

The Secretary:—"2. Throw, 5 in. at center line of No. 1 rod."

"3. Gage of Track, 4 ft. 8½ in."

"4. Switch Rails. Side planing and bending shall conform to a spread at the heel of 6¼ in. between the gage lines of the stock rail and the switch rail. The gage lines of switch rails shall be straight. The head of switch rail shall fit neatly against the head of stock rail from point of switch rail to point of divergence. The face of web at the point shall be in a vertical line with the inside edge of the head of the stock rail."

Mr. Lindsay:—I think in connection with this paragraph on switch rails we will have to take into consideration the drawing. The drawings do not show the bend in the stock rail, and therefore are not complete. The paragraph at the bottom of page 8 of the Bulletin refers to the face of the web. The web has two faces, and in another part of the report they refer to the particular face they intend here as the "outer face." I think it is proper to say that the outer face of the web shall be in a vertical line with the inside edge of the stock rail. I think, too, that it would be better if the words "gage side of the stock rail" were used.

Mr. Knickerbocker:—We found in some cases, where the manufacturer did not put in a stock rail, and we had to put that in the track, that conditions are not the same on all railroads, and the distance from the bend in the stock rail is not yet uniform. We could not go into that question now, and the general proposition connected with it is the one as to the bend in the stock rail to any particular point, and is matter for consideration another year.

Mr. Lindsay:—I cannot see how they can specify how the points shall be planed and not show a drawing of it. Is the intersection of the gage lines at the point, or at some distance in advance of the point? I cannot see how they can make an intelligent report unless they define the location of the apex of the angle. It may be that the practice is one of the things for this Committee to determine and recommend. I move that the Committee be instructed to definitely locate the bend in the stock rail on the drawings.

Mr. Rose:—The tables published last year by the Track Committee show the bend in the stock rail, and on page 12 of this report is shown the details of the point. If a manufacturer has the point of the switch rail itself given to him, it seems to me that he can make the switch point, provided the heel distance is given. He does not need to know where the stock rail is bent; but we did have last year a drawing showing the bend in the stock rail.

Vice-President Cushing:—Is that drawing of last year the same thing as this drawing?

Mr. Rose:—Yes; that drawing was similar to the details of the point shown here, but is not republished because it is not a part of the specifications.

Mr. Lindsay:—If that is true, then the drawings are not complete. The specification goes on to say that the gage line shall be straight. That implies that the stock rail shall also be straight for a given distance. Otherwise you would have to plane the opposite side curved.

Mr. M. L. Byers (Missouri Pacific):—It strikes me as a matter of specification that this detail is not absolutely necessary. We might compromise this matter by asking the Committee to report as one of the subjects in connection with the investigation of track matters, on how the stock rail shall be bent, and at some later time give us that information. In the meantime we can go on with the discussion of the specification and get through with that, and I would move to amend Mr. Lindsay's motion to the effect that the Committee be asked to report on this question of the bend of the stock rail as an independent proposition later.

Mr. Lindsay:—Are not the plans a part of the specifications? Are not the specifications adopted when we adopt the conclusions of the Committee?

Vice-President Cushing:—I so understand.

Mr. Lindsay:—Then do we require a motion to adopt these plans?

Vice-President Cushing:—It means the acceptance of the incomplete plans until further action. Mr. Byers' amendment is that the subject of bending the switch rails be referred back to the Committee for further investigation and report, and that means that these incomplete drawings will be accepted.

(The motion was lost.)

Vice-President Cushing:—The question now is on Mr. Lindsay's original motion.

Mr. W. M. Camp (Railway and Engineering Review):—I would like to ask Mr. Lindsay what he means by defining the bend in the stock rail. Do you mean to specify just where the bend shall come?

Mr. Lindsay:—To define the location of the bend in the stock rail with reference to the point of the switch.

Mr. Camp:—I think it is quite an essential point in a switch to determine just where that point comes. It is the practice of a good many to shield the switch point by putting the bend in the stock rail a considerable distance ahead of it, while others place the point up too close to the bend.

Mr. Rose:—The Sub-Committee of this Committee has determined where that bend will come in the tables published, I think last year, for the length of lead. Mr. Camp has brought out the point that some roads shield the point by making the bend in one place, while other roads do not shield the point. I submit that that is not a part of the specification for the manufacture of switches, but if it will satisfy Mr. Lindsay, I think we can add to these drawings the distance from the toe of the switch to the bend in the stock rail, as previously figured out by this Committee, and that can be readily done and added to these drawings, if that will be of any benefit.

Mr. Lindsay:—That is satisfactory.

The Secretary:—"Top planing shall conform to the measurements shown on Fig. 1 and Table 1.

Switch.	A B
33 ft.	12 ft.
22 ft.	9 ft.
16 ft. 6 in.	5 ft.
11 ft.	5 ft.

"Bottom of switch rail shall be planed to fit neatly on base of stock rail where bases overlap.

"The point of switch rail shall be as shown by Fig. 2.

"Holes for switch rod lugs and stop blocks shall be 25/32 in. in diameter and 5 in. center to center. Holes for reinforcing bars shall be 25/32 in. diameter. Number and location as provided under Reinforcing Bars."

Mr. J. G. Sullivan (Canadian Pacific):—I fail to see here the distance that is planed on the switch rail. Of course that depends on the angle that the stock rail is bent to. Is that given in tables? That is, at what point do you begin cutting the head, how far from the point?

Mr. H. T. Porter (Bessemer & Lake Erie):—On page 12 of the report you will find a section of the point. These specifications are supplemental, and in that part of the specification adopted last year the spread of the rail is fixed. These specifications state that the gage side shall be straight, so that the two points, at each end of the back of each side, shall be straight, fixes the length of the plane, if you start to figure it out on the plan.

Mr. J. G. Sullivan:—Have you stated at any place that the stock rail is straight from the point?

Mr. Porter:—Not stock rail—the switch rail.

Mr. J. G. Sullivan:—You can bend the stock rail after you pass the planing point, to get your clearance.

Mr. Camp:—I think Mr. Sullivan is right about that. We are not referring to the bend of the stock rail, but to the point where the stock rail begins to curve after passing the bend. That matter of planing is an important feature, and if the stock rail is to be curved where the switch rail rests against it the length of the planing then becomes important.

Mr. Rose:—The drawings show the stock rail is straight.

Mr. Porter:—If you make the gage side of the switch rail straight, you will have to make the stock rail straight.

Mr. Jenkins:—If the switch rail is straight and the gage uniform at 4 ft. 8½ in., the stock rail must necessarily be straight as far back as the heel of the switch.

Mr. Camp:—If that is the case, the stock rail ought to be straight. It does not necessarily have to be, but it ought to be. To fit properly against the planing of the switch rail, the stock rail ought to be straight.

Mr. Edwin F. Wendt (Pittsburgh & Lake Erie):—I would like to ask respecting the drawing at the head of page 10, whether the end line should be a full line or a broken line. Is the drawing intended to show the end of the switch rail?

A Member:—This drawing is looking sideways on the gage side, not on the outside rail.

Mr. Chas. S. Churchill (Norfolk & Western):—If I am mistaken in this matter, I wish the Committee would inform me. It seems to me this discussion is brought up largely by the fact that there is no distance given between the stock rail and the heel of the switch.

Mr. Rose:—It is given in the specification, in clause 4.

Mr. Churchill:—That fixes it, then.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I think we are losing sight of the fact that these specifications are for the manufacturer, and not for the trackman or the sectionman, and if we confine our discussion to features that affect the manufacturer of the material, we will make progress.

Vice-President Cushing:—If there is no further discussion, we will pass to lugs.

The Secretary:—"5. Lugs. Lugs shall be as deep as the section of rail will permit and of standard design, as shown in Fig. —. Distance between centers of holes for bolts running through the web of the rail shall be 5 in., diameter of holes shall be 25/32 in.

"Distance between web of rail and center of switch rod bolt holes shall be 5 in. Switch rod bolt hole shall be 1 1/32 in. in diameter."

Mr. Lindsay:—I move that the words "inner face" be inserted before the words "of the web."

(The motion carried.)

Mr. F. J. Parrish (Kentucky & Indiana Terminal):—In regard to the drawing on page 12, has the Committee anything to offer in reference to measuring the distance?

Mr. Rose:—That has to do with the lugs. That would define the point of the web.

Mr. Knickerbocker:—That distance would not be the same for any size of rail, and if we should undertake to give you a table for all sizes of rail we would have to go further than our report now includes. We only give you a general outline, and when the Association so instructs us, we will give you the details. We are trying to give you general specifications for the manufacturer.

The Secretary:—"6. Switch Rods. Switch rods shall be of the standard design, as shown in Fig. —. Rods shall be ¾x2½ in. and shall be held in a horizontal plane. Bolt holes shall be 1 1/32 in. in diameter. There shall be at least 1½ in. of metal at end beyond bolt holes.

"Rods shall be stamped with ¾-in. letters showing the weight, section of rail and number of rod, the point rod being No. 1."

Mr. R. G. Kenly (Minneapolis & St. Louis):—My remarks will take us back to the measurement that we just voted on, that the web of the rail from the center of the bolt hole be 5 in. I would like to ask if the Committee has investigated the proposition to make all of the switch rods exactly the same length between the bolt holes; and make the variable distances for the different weights of rail, from the center of the web to the center of the hole in the lug? I had some experience many years ago, when a track foreman got hold of a rod with a long spacing between the bolt holes on a switch rod and he put it on a switch that had lugs that had a wrong distance from the web of the rail to the center of the hole in the lug, with the result that he had the flange of the rail between the open switch point of the main rail much less than it ought to have been. The foreman was fairly intelligent, too, but with the foremen that we are coming to nowadays, and with your uneducated trackman, send that man down to the tool house to get a rod for a 90-lb. switch, and instead of getting the one that is stamped according to the last paragraph of this recommendation in respect to switch rods, he gets a 100-lb. switch connecting rod. It fits on the same switches, pushing the switch points further apart and reducing the flangeway between the stock rail and the switch point. I think this is worthy of investigation.

Mr. Knickerbocker:—I might say that we have thought about that a great deal, and it would be an advantage for the lugs to be marked.

Mr. Kenly:—My recollection is that it was the switch point on the high side of the curve which had to be replaced, and in doing it we got hold of a switch point that had long lugs on it.

Mr. Knickerbocker:—On page 12 of the report a little diagram is furnished, and if that is followed there will be no rivets in those five holes shown, because it will be necessary for this switch to be put in an interlocking plant, the same as a switch put out in the country. The switches shown there have been carefully gone over by the Committee with the Signals and Interlocking Committee, and the whole matter has been straightened out. If those are riveted, you will have trouble all the time. You cannot put them in an interlocking plant without cutting the whole thing out, or renewing the switch point. We have tried to make it easy to interchange the switch points at any point on the line. We have done so in the diagram, and we would like to have the five holes go.

Mr. Kenly:—When the switch points are furnished by the manufacturers, showing the lugs bolted fast to the rail, the order is placed for switches that are to go into an interlocking plant, or those that are not to go into an interlocking plant, and there is much less occasion for changing a lug on a switch point than there is for changing the rod on a switch point. Far more frequently the connecting rod has to be changed than the lugs.

Vice-President Cushing:—Do you wish to cover this by motion?

Mr. Kenly:—No, sir; I am merely seeking information.

Mr. Knickerbocker:—This diagram shows 12 in. from the center to the end of the point, the distance from the center of the next two holes is 17 in., which is required.

The Secretary:—"7. Reinforcing Bars. A reinforcing bar ⅜-in. thick shall be riveted to each side of each switch rail and point ends shall be made flush with point of switch rail. The bars shall be as long as the heel connections will permit. Bars shall fit against web of rail and shall fill the space between head and flange of rail. There shall be ⅛-in. clearance between outer bar and head of stock rail where the bar projects under head of stock rail, and the top of inner bar, where it projects beyond the head of switch rail, shall be not less than 1⅞ in. below the top of stock rail.

"Bars shall be fastened to rail with ¾-in. rivets, except that the first, second, fifth, and the holes through which the lugs are fastened shall be bolted. Center of first hole shall be 1½ in. from point, and center of last hole in bar to be 2 in. from heel end of bar. Intermediate rivets shall be spaced so that there shall be fastenings at intervals not greater than 12 inches."

Mr. Lindsay:—The section under consideration contains the following sentence: "Bars shall fit against web of rail and shall fill the space between the head and flange of rail." That is all right, as long as there is any head on the rail, but at points where switches are operated by interlockings, the space of one-eighth of an inch is entirely too small. When there is snow and ice the ⅛-in. space becomes filled up with a thin film of very hard ice, and this interferes with the operation of the interlocking apparatus, especially where it is of the highest grade and where the adjustment is down to the thirty-second of an inch. I would like to see that increased to ¼ of an inch, and the reinforcing bar should be beveled to an angle of 45 degrees where it projects beyond the head of a rail, so that there will be an opportunity for anything which accumulates on the upper surface of it to be forced off.

I move that in the last line on page 10 of the report the distance of ⅛ in. be increased to ¼ in., and that at the end of the first paragraph on page 11, after the words "top of stock rail," there be added: "The reinforcing bar shall be beveled to an angle of 45 degrees where it projects beyond the head of the rail." That is the New York Central practice at the present time.

Mr. F. P. Patenall (Baltimore & Ohio):—I ask whether the Association now has any standard in that direction; especially in reference to the ⅛-in. clearance. Naturally we all have trouble in snowstorms, but I do not think that trouble would be any greater or any less if the change were made from one-eighth to one-quarter.

Mr. Knickerbocker:—In going over that matter we considered the vertical movement of the switch point in the head of the rail, and we concluded that the less distance we could properly have the better it would be to get a free movement of the switches, because we thought the continual movement of the switch point vertically would be taken care of to a certain extent by a reinforcing bar under the head of the rail.

Vice-President Cushing:—I will put Mr. Lindsay's motion in two parts. We will first vote to increase the clearance from ⅛ in. to ¼ in.

(The motion was lost.)

Vice-President Cushing:—The second part of Mr. Lindsay's motion applies to page 11, where he desires inserted after "stock rail," on the third line, the words "the reinforcing bar shall be beveled to an angle of 45 degrees where it projects beyond the head of the rail." Is there any discussion on this point? The Committee has no objection to taking that in, and it is accepted by the Committee.

Mr. B. H. Mann (Missouri Pacific):—The last paragraph under the heading of Reinforcing Bars could be a little more definite as to the spacings of the rivet holes back of the part shown on the detail drawing, on page 12, particularly with reference to the possibilities of planing down the broken point, and making a new point. The question has been very carefully covered in specifications of several railroads. General instructions of this sort, it seems to me, would be apt to mislead the manufacturer if the importance of uniform drilling is not brought out more clearly than it is in this case. I would like to know from the Committee as to whether there would be any objection to changing the sketch so that the drilling will be shown the complete length of the point. Then if a 16 ft. 6 in. point becomes broken, so that it can be planed down to a point that is 11 ft., all that will be required will be to cut the reinforcing bars, using the same holes for the rivets in the new length and at the same time the interlocking feature will be protected at the tip.

Mr. Knickerbocker:—We would like to do that, but until we can determine whether we can use the same distance from the point to the center of the throw rod of a hand-thrown switch as with an interlocking switch, we cannot do it. After that comes we will give you the spacing.

Mr. Patenall:—In support of the Committee I would say that it seems the drilling shown on the diagram is correct, inasmuch as if the switch point breaks at a hole, nothing would be gained by showing the other special drilling needed on these plans.

Mr. Mann:—The point brought out by Mr. Patenall is a good one, but we should understand what it means to change the spacing of the drilling from 1½ in., 5 in. and 5 in. to 1½, 5 in. and 3 in. It means the spacing of the ties 2 in. closer, and that in turn means less expensive maintenance in taking care of the track. It seems to me that this should be brought out clearly on the question of costs.

Mr. W. H. Elliott (New York Central & Hudson River):—The drilling in Fig. 2 is presented as being the best from the standpoint of the Signal Engineer as well as that of good track maintenance, and I hope that the drilling shown will be approved. It provides for the best signal construction, giving better support to the point than the drilling now used, and which Mr. Mann refers to.

The Secretary:—"8. STOP BLOCKS. Stop blocks shall be of approved design with two holes 13/16 in. in diameter and 5 in. apart. Blocks shall be spaced after switch is placed in track as nearly as practicable at equal intervals between the end of planing and heel of switch."

Mr. W. C. Barrett (Baltimore & Ohio):—I would ask if it is the intention to place the blocks after the switches are put in the track. Cannot they be placed more economically and easier before the switches are put in the track?

Mr. Knickerbocker:—That would be all right if you always had a straight track, but where you have a curve on the inside, leading out on the inside of the curve, the radius changes and unless your block is put in after the switch is in the track, it does not touch the stock rail.

Mr. Kenly:—Is it possible to give us some recommendation as to what the design of that stop block shall be as to the thickness and width of the metal?

Mr. Knickerbocker:—We will give that to you when we get instructions to do it. We are trying to give you general specifications, but are not going into details.

The Secretary:—"9. BOLTS AND NUTS. Bolts fastening lugs and stop blocks and foot guards to switch rails shall be ¾-in. in diameter. Bolts connecting lugs with switch rods and the switchstand connecting bolt shall be 1 in. in diameter and machine turned. All bolts shall be provided with nut locks and cotters. Nuts shall be hexagonal."

"10. PLATES. There shall be on each tie two plates, ⅞-in. by 7 in., planed down to receive the stock rail and braces. Three 15/16-in. holes outside and two inside are required for ⅞-in. lag screws or screw spikes on all switch ties, except the two head ties, where there shall be three outside and four inside."

A Member:—The Committee has made no provision in this 7-in. plate for spiking the switch in its proper position when it is necessary to disconnect it from the switchstand or interlocking apparatus, and I think they should do so. I move that the Committee provide in the plate which goes on the two head block ties two holes of the proper dimension in each plate and properly located so that the switch can be spiked when disconnected from the switchstand or from the interlocking apparatus.

(The motion carried.)

Mr. W. H. Elliott:—In that connection, it is my understanding that one hole is to be placed in each piece of tie-plate; two holes are required for each tie, and for the two ties which are plated as shown there will be a total of four holes drilled.

The Secretary:—"11. BRACES. Braces shall be of such a design that 2½ in. clearance for detector bars may be obtained. Three holes for ⅞-in. lag screws or screw spikes shall be provided."

Mr. Knickerbocker:—The Committee moves that what is given in this section of the report, as amended, shall be accepted as the conclusions of the Committee and approved.

Mr. Wendt:—I do not know what effect the adoption of the diagrams may have on the legal responsibility of railroads. We all know from experience that it is not necessary from the standpoint of safety to equip all slide plates with braces. A multiplication of braces adds to the expense. Is the expense justifiable? If these diagrams are approved and printed as the recommendation of this Association, does that carry with it the responsibility for placing braces on each slide plate? It is not necessary, in my judgment, to increase the expense of switches in that particular manner. The switches as proposed are the very best that could be designed from the standpoint of slide plates and braces. There are few railroads in this country, if any, which use switches of this standard. You will notice that the tie-plates extend two ties beyond the heel of the switch. There may be only one, or two, or possibly three roads in the country that have a standard of that kind. If it is necessary to burden the railroads with all the expense for additional slide plates and additional braces, let us say so, and then let us advocate the appropriation of the money for the work.

My personal opinion is that the first two slide plates should be equipped with braces, and after that it is perfectly safe to equip every other slide plate with a brace. I am using this point simply by way of illustration.

Mr. Patenall:—I do not agree with the previous speaker. There has to be a certain period of transition from good to better. The transition necessarily should be in the way of improvement. If railroads do not follow improved methods, I am afraid we would get into a bad state of retrogression. However, I do not see that we are taking any great responsibility, in point of law, by making such improvements as may become necessary, and I believe the Committee ought to be sustained in its report.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I am quite in accord with the remarks made by Mr. Wendt. I should be opposed to a motion that this convention adopt the report of the Committee, and if it is in order I move that the report of the Committee be received as information. I think it will be just as valuable to the membership of this Association if it is received as information as it would be if adopted, and it will not involve as great responsibility on such railroads as may not care to follow its recommendations.

Vice-President Cushing:—There is a motion before the convention, and as your motion is contrary to it, it will be necessary to vote down the question on the first motion made.

Mr. Rose:—I think the point raised by Mr. Wendt is a fine legal question, and one would require legal experience to decide it. Any action taken by this Association can be brought under the same general category—if we were to design a switch with one brace and some railroad happened to leave that brace off the switch, we would be in the same position. I think if we follow that reasoning to the limit, every action we take would come under the same heading.

Mr. Lindsay:—I hope the motion will not prevail. I think it is evident from the relatively small mount of comment that has been made by the members that they have not had the Bulletin in hand long enough to study the details of the report and consider the fine points of it. I believe the Committee will acknowledge there are several points that have escaped their attention, and perhaps there will be more. I hope, therefore, that this motion will not prevail, and that the subject will be referred back to the Committee for another year's consideration.

Mr. Knickerbocker:—This report was handed in several weeks ago, and if the members have not had an opportunity to peruse it, that is not our fault. If you wish to make things better you have got to go somewhere else than to the Committee. We had the report ready on time and there should have been lots of time for everybody to look it over; the objection made does not make the report any worse, and that is no reason why you should object to it.

Mr. G. D. Brooke (Baltimore & Ohio):—I would like to ask the Committee if they have made any effort to obtain information as to how near these diagrams represent the general practice in the use of braces on the ties shown?

Mr. Knickerbocker:—The only thing I can say is that some railroads use two tie-plates with two spikes and some with three spikes. There are other roads that use the tie-plates with a brace on each end. We took the position in our report that we thought it was proper to take. We cannot get a general standard to fit all conditions—we have offered the best we can. When we came to look up the plans of the railroads which we had in our hands we found that the standards were one thing and what they had in the track was different. Their intentions were good, but they did not live up to them. We want to make them as good as we can. It is the same way in the case of the report of the Ballast Committee—that Committee says there should be broken stone under the track, but on many railroads we can get along without it in many places. The use of broken stone under the track is an ideal condition, which we all should look to. That is exactly what we have done in this report. We have presented to you what we considered to be the best practice.

Mr. Loweth:—I want to inquire what the motion before the convention is?

Vice-President Cushing:—The motion is that this report be accepted.

Mr. Loweth:—Would it be proper to offer as a substitute motion that this report be received as information instead of being adopted?

Vice-President Cushing:—I think it would be better to put the original motion.

Mr. Porter:—The Committee has found by pretty thorough investigation that there is no one plan of switches that all the railroads will follow. We sent to most of the railroads for their standard plans, and I wrote to every frog and switch maker in this country for a copy of their standard plans. We found that a great many of the smaller lines were following the plans of the larger lines, and we attempted to get up a design, as near as we could, conforming to what was accepted last year, of a standard switch. We were not asked to get up a switch that would simply be safe, because we could have gotten up one very much simpler that would be safe under such reasonable inspection as switches get on a railroad, but we did try to design a switch that would ride as smoothly and comfortably, so far as we were able to do so, as that portion of the track where there is no switch, and we also endeavored to design a switch that had the longest possible life. The probabilities are that we would obtain economy in the end. Every year sees improvements in the design of switches and an increase in the cost of the switches that are used. The primary object of our efforts was not to make them simply safe, but to make them ride smoothly and secure ultimate economy. History shows that railroads are gradually adding more rail braces to their switches. We put on all that we could get on, for the purpose of holding it in line, of keeping the rail from running and of keeping the switch for a long time in its original condition of efficiency so that it would not be necessary for the section gang to be tinkering at it every few days. I believe the convention yesterday expressed the sentiment that we should look ahead twenty years in the design of our railroad terminals. In the case of the designing of switches, we have not anything that is more expensive or better than what is in use to-day somewhere.

Mr. Camp:—I believe this question came up over the matter of rail braces. I think the Committee is rather extravagant in the use of rail braces. The object of rail braces at a switch is to take the unusual side thrust of the locomotive or car in entering the switch, and that comes at the point where the track changes direction. According to my observation, it is not usual to have braces all the way to the heel of the switch rail, especially when switch rails 33 ft. long are used. I do not see how safety is to be promoted by having braces back of the rod which comes at the end of the planing. All of the force of the lateral thrust comes against the switch rail where it bears against the main rail. That is the part to be protected. It looks more substantial, perhaps, to see braces running back to the heel joint, but I do not consider that it is any safer than to omit, say, half the braces on switches of 33-ft. length. Two spikes can be driven through each plate outside the rail, which will hold the rail very securely.

Mr. Lindsay:—I think the Committee and Mr. Knickerbocker misunderstood my remarks. I had no intention of criticizing the Committee for the late arrival of the Bulletin. The Committee has done excellent work, as shown in this report. I ask, will anything be sacrificed by postponing the action in reference to printing the conclusions in the Manual for a year, and allowing Mr. Loweth's motion to prevail?

Vice-President Cushing:—The question is on the adoption of the report as amended.

(The motion was lost.)

Mr. Elliott:—I am very sorry that with the loss of this motion the Association takes no action on the drilling of the switch point, as shown on page 12. This is a matter with which signalmen are particularly concerned. The drilling proposed does not call for a change in the present standard of drilling where the switches are operated by hand stands, but does require that the bolt holes necessary for interlocking connections shall be drilled at the shop, and will not have to be done by hand in the field.

Therefore, in the interests of interlocking signal work, I move that the drilling of the switch point, as shown on page 12, Fig. 2, be adopted.

Mr. Mann:—In line with Mr. Lindsay's suggestion, it seems to me that as far as interlocking is concerned, postponing consideration of this for a year will not be a bad feature, for the reason that spacing of the drilling of the holes for the rivets and lugs of the No. 1 and No. 2 rods, particularly the No. 1 rod, is reduced two inches. In interlocking work that means that between the front rod and No. 1 rod we will have two inches less space for the switch point to "run." In such an arrangement the operating rod will have so much less space to avoid the rub against the edge of the tie. That means that extra cost for maintenance will be required, as far as section labor is concerned, in preventing interlocking plants being put out of service due to the lever working too hard on account of a rod rubbing against the tie. It seems to me it would be better to plan first for the change in signal material to adapt itself to these new conditions. As soon as signal standards have been changed so as to maintain the same space that we have now between the front rod and the operating rod, so as to protect the operation of the interlocking, it would be time to talk about drawing these ties closer together and decreasing the track maintenance.

Vice-President Cushing:—I will make a suggestion, as there seems to be so much difference of opinion about these matters. My suggestion is that Mr. Elliott withdraw his motion and let the report as a whole be disposed of one way or the other.

Mr. Elliott:—I withdraw the motion.

Mr. Loweth:—I move that the report be received as information.

(The motion carried.)

The Secretary:—"Conclusion (4) That the plans for rigid and spring frogs, submitted with the report, be adopted and added to the specifications for the frogs, crossings and switches."

Mr. Churchill:—I move that this be received as information.

(The motion carried.)

The Secretary:—"Conclusion (5) That the specifications for switches submitted be adopted and added to the specifications for frogs, crossings and switches."

Vice-President Cushing:—That has been acted on and it will not be necessary to consider it further. It is not necessary to consider conclusion 6, as that is a progress report.

The Secretary:—"Conclusion (7) That the report on Spirals be adopted."

Vice-President Cushing:—On page 4 the Committee seems to have introduced a number of recommendations in connection with spirals, and

I presume it will be the desire of the Association to have the sub-divisions on page 30 of the Bulletin, in connection with spirals, read.

The Secretary:—"(b) Adjustment of Curves, with consideration as to Easement Curves.

"Longer easement curves than the minimum lengths recommended may be used to advantage and often with increased convenience in their application, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration as to the effect on cost. *For minor curves, an increase in length of about 50 per cent. over the minimum is recommended when such increase will not seriously affect the cost, nor adversely affect the degree of curve.*

"The minimum length recommended should be used in all cases where a greater length would adversely affect the degree of curve."

Vice-President Cushing:—If there is no objection, it will stand approved.

Prof. Talbot:—I desire to suggest two slight modifications in the form of the table on page 29 of the Bulletin. The first is in the heading of the table—for the word "deflections" substitute the words "deflection angles," since that is the notation used on page 22, which the Committee also asks be printed. The other is that the table be changed in form so that the co-efficients read down the column for the transit at any given point instead of across the page. This will be very much more convenient for use.

Vice-President Cushing:—The suggestions are accepted.

Prof. Talbot:—In the upper left-hand part of the diagram of minimum length of easement curve (facing page 30) is given a limit of length of curve for superelevation of two inches. It will be seen by using these formulas, that the amount of throw of track from what it would be for a tangent and circular curve is less than one-quarter inch for all of those opposite that particular dotted line, since the departure of an easement curve from the tangent and circular curve with which it should be compared is never more than 1/20 and since the Y of the end of the spiral is not a governing consideration. The last sentence of the printed matter reads: "Spirals need not be used when superelevation required for highest permissible speed is less than two inches." I wish to suggest the addition of the words "nor when the distance between the tangent and the parallel tangent of the off-setted curve is less than 0.2 ft." I am not anxious about this particular value, but I feel that the limit given in the diagram is much too low.

Mr. Jenkins:—Take a thirty-minute curve and a speed of about eighty miles per hour—I think a spiral would be desirable there, because it would greatly reduce the shock of contact between the flange of the wheel and the outer rail; and in fact for any of the lighter curves, say one degree or lighter at a very ordinary speed, in the neighborhood of sixty miles per hour, the same thing would be true. The Committee covered this point last year in a discussion of the effect of very short spirals having small offsets and a limit was fixed so that the spiral would be omitted when it would not govern the path of the wheel at all, but when the spiral would produce any appreciable effect on the motion of the train, it would be introduced. A circular letter was sent out by the Committee asking the minimum offset used for spirals; in the answers we received, some favored the use of spirals in all instances, regardless of how small the offset was, and some favored spirals with a minimum offset of one-hundredth of a foot instead of two-tenths as suggested.

The Committee took four-hundredths of a foot as being the practical minimum.

Prof. Talbot:—I would like to make sure that this Association feels that track can be put down to 0.01 ft., as just mentioned, and that it would pay to put in a spiral where the track would not be shifted from a tangent and circular curve more than 0.02 ft., or a quarter-inch. The Committee recommends that it be made 50 per cent. longer than this, even then a small amount. My own view is that for such conditions a well alined tangent and circular curve, with the superelevation attained on the tangent, will accomplish all that the easement curve will do.

Vice-President Cushing:—Do you wish to make a motion covering your suggestion?

Prof. Talbot:—I make the motion that the following words be added at the end of the printed matter: "Nor when the distance between the tangent and the parallel tangent of the off-setted curve is less than two-tenths foot."

Mr. Jenkins:—I would like to call the attention of the convention to the fact that the ordinate Y at the S. C. is about four times the offset, and the suggested limit of two-tenths of a foot for the offset would make the smallest value of Y at the S. C. to be used, eight-tenths of a foot. I think that is a little too great. The Committee's recommendation making the minimum offset four-hundredths makes the smallest ordinate for the end of the spiral sixteen-hundredths of a foot; with this offset the rail will guide the flange of the wheel through considerable portion of the spiral.

(The motion was lost.)

Mr. Jenkins:—Before we leave this point, it is proper to remark that the Committee had no intention at first of presenting any new or original matter, but our investigations soon determined the necessity for much that is original in the way of formulas and also in the treatment of the subject. But to a considerable extent the work is a review of what has been done before, and the Committee has no intention of claiming originality for such matter. The table of co-efficients for deflection angles, for instance, has previously been published in various forms in several books and articles on spirals, and the notation for curve points was mainly originated by Mr. R. M. Merriman; the Committee in its report has not given credit to anyone for previous publication, and takes this opportunity to disclaim originality for any matter which has been published before.

Vice-President Cushing:—The Secretary will read recommendation 2.

The Secretary:—"(2) Following the last paragraph under section (b).

"Your Committee recommends that the following be added:

"The 10-chord spiral, computed by dividing the spiral into 10 equal parts, is recommended. Chords of any length may be used in taking out the 10-chord spiral when the central angle is small. Chords approximating one-tenth the length of spiral should be used when the central angle exceeds 15 degrees."

Mr. J. G. Sullivan:—This Association has cleared up one point that has heretofore been a source of a great deal of trouble, that is, the definition of "degree of curve." The degree of curve is now acknowledged to be the angle subtended by a 100-ft. chord.

It seems to me that the Committee are making a mistake when they say chord of any length may be used. I should think they would be justified in recommending that in computing tables that the same system be followed that we do in computing tables for the functions of a simple curve being measured by 100-ft. chords. We would then get a very desirable result, namely, tables would be uniform and for a certain rate of change, the first half of a spiral on a 10-degree curve would be exactly the same as a spiral for a 5-degree curve.

If we followed the suggestion of the Committee, we will have a worse mixup in tables than we have had in tables of simple curves, when some authors were using one method, others another, and still others a combination of the two.

Mr. Jenkins:—I would like to say that the idea of Mr. Sullivan is a very good one, and one that the Committee only wishes could be carried out. I wish to call attention to the excellent article of Mr. Sullivan in a discussion of this point, which will appear in a later Bulletin. Mr. Sullivan's idea was the first one on which the Track Committee worked in trying to derive formulas for the spiral; but as spirals for different degrees of curve would have somewhat different relations between the values of the functions and the total central angle, it seemed that they could not be expressed by a single series of formulas. It would be a very easy matter to write out a table for the spiral which Mr. Sullivan suggests, for any particular rate of increase of curvature, without formulas, treating it practically as a compound curve; but it seems to be impossible to devise a set of formulas that would be applicable to all curves and all rates. The Track Committee abandoned the attempt after an earnest effort to accomplish what Mr. Sullivan suggests.

Mr. J. G. Sullivan:—Do you find that your error in using a 10-ft. chord versus a 100-ft. chord, or a 20-ft. versus 100 ft. will be greater than the discrepancies that you will get by neglecting correction in your formula? Your correction does not amount to anything until you get up to a 5-degree 30-minute curve or 6-degree curve.

Mr. Jenkins:—For light spirals, it would make very little difference whether we use the formulas derived by Prof. Talbot or Prof. Crandall, or those of many other authors. When we come to use spirals of high central angle, then the character of the formulas makes considerable difference; there are certain well-known approximate formulas that will apply almost equally well to all spirals of small central angle; but we cannot make these same formulas which apply to a spiral 300 ft. long to a one-degree curve, apply satisfactorily to a spiral 200 ft. long to a 20-degree curve. The Track Committee has obtained new formulas that will apply in all cases, with a degree of accuracy that can be considered exact, within a limit of 45 degrees of central angle.

The Secretary:—"(3) Maintenance of Surface.

"Your Committee recommends that the third paragraph following the table of elevation of the outer rail read as follows:

"Ordinarily an elevation of eight inches should not be exceeded. *Speed of trains should be regulated to conform to the maximum elevation used.*"

Vice-President Cushing:—Any discussion? If not, the Secretary will read No. 4.

The Secretary:—"(4) Maintenance of Surface, section (a), recommended practice.

"Your Committee recommends that the following paragraph be stricken out:

"In ordinary practice it is recommended that the elevation be run out at the rate of one inch in 60 feet, but this will be modified by the same conditions that would vary the length of the easement curve used.

"(5) Maintenance of Gage, section (a).

"Your Committee recommends that paragraph 1 read as follows:

"Tie plates are recommended in all cases where economy in maintenance will result from their use."

Vice-President Cushing:—Any discussion? If not, those paragraphs will be accepted.

The members will please turn to page 30 of the Bulletin. In the middle of the page there are some more recommendations in regard to change in the Manual. Are there any additional comments in regard to the Track Committee's report? If not, the Track Committee will be dismissed with the usual thanks of the Association.

Mr. McDonald:—Before dismissing this Committee, I think it would be in order for the Association to express its thanks for the large amount of careful work that they have done, and I make a motion to that effect.

(The motion was carried unanimously.)

REPORT OF COMMITTEE IV.—ON RAIL.

(See Vol. 12, Part 2, pp. 3-559.)

DISCUSSION.

The President:—We will now take up the consideration of the report of the Committee on Rail. Mr. Chas. S. Churchill, the Chairman, will present the report.

Mr. Chas. S. Churchill (Norfolk & Western):—The first recommendations of the Committee, and the reasons therefor, are given on page 10 of the Bulletin under "Revision of Manual." It is believed by your Committee that the subject matter of temperature expansion for laying rails in the 1907 edition, page 53, belong to Committee on Track, and they recommend that it be transferred. In conclusion (1) our recommendation is that "Temperature expansion for laying rails, Manual, 1907 edition, page 55, be transferred to the chapter in the Manual containing the approved resolutions of Committee on Track."

The President:—Unless there is objection to that, the Committee's recommendation will be adopted.

Mr. Churchill:—"2. That the 'Form for Reporting Rail Failures in Main Tracks, M. W. 1200,' be replaced in the Manual by form 'M. W. 404, Report of Rail Failures in Main Tracks.'"

This is in answer to suggestions at the last meeting. Mr. Lindsay recommended a change, and the Committee promised to look into this matter. It is important to show the gage side in case a rail fails, and this is the most important change or addition. The numbers on the form were slightly re-arranged to make it simpler and more concise, and the recommendation is that this slightly modified form be adopted.

Mr. C. E. Lindsay (New York Central & Hudson River):—There is an important feature in regard to the condition of track; the bearing of the rail upon the tie, whether it has a full bearing or not; it is quite as important as some of the other features of track. The section foreman's information is not always reliable; he dodges behind the witnesses' bulwark, that he does not have to give any information that would incriminate him. He will report that the track was all right, joints all right, roadbed all right, yet the rail broke. I believe we should have a question in there, "did the rail have full bearing upon the tie plate?"

Mr. Churchill:—I am a little afraid that we would get the same sort of an answer. We believe, where a break occurs, that is not very clearly explainable at first sight from the foreman's report, there should be an examination by somebody else much higher up than the track foreman, and I think that is the practice on most of the roads to-day. I think, if we make the report too cumbersome, we will not get it answered in an intelligent manner.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis) :—I have heard some criticism offered on our annual reports to be made by section foreman, as to No. 7 on the back of the report, "Rail damaged." The criticism was that to report rail damaged in a wreck simply complicated the matter of the study of the rail question, and I would like to ask the Committee whether they consider it of importance that rails damaged in a wreck should be reported.

Mr. Churchill:—This Committee does not ask that rails injured in wrecks be reported, and many roads have a special form for reporting rails damaged in wrecks. The object of descriptive clause No. 7 in this form is that as soon as a report is received showing that a rail is broken because of a wreck, no further attention is to be paid to that particular rail breakage; it is not put into the reports of rail failures. It belongs somewhere else, being charged to wrecks.

Mr. McDonald:—Then it is not the desire of the Committee that rails damaged in wrecks shall be included in the annual report made to the Committee?

Mr. Churchill:—No, sir; we do not wish it there. The recommendation, therefore, is for the adoption of conclusion 2.

The President:—If there is no objection, the conclusion will be adopted.

Mr. McDonald:—Following up the remarks I have made, the Committee has made provision on form 405, column 21, for rails damaged in wrecks.

Mr. Churchill:—I call attention to the fact that form 405 is one that will not come before this Committee in the future. It is not a form for reporting rail failures to this Association. It is simply a superintendent's report for tabulation of rail records.

The President:—Is there any objection to the adoption of form 404? That is practically the form now in use, with the modifications explained by the Chairman with reference to indicating the gage side of the rail. If there is no objection to the adoption of form 404, we will pass to conclusion 3.

Mr. Churchill:—"3. That the changes in form M. W. 405 (old No. 2002-B) be approved, and the form included in the Manual."

The adoption of form 404 makes necessary a slight change in form 405, for the reason that the information on the back of 404 having been changed, the corresponding information on the back of 405 must be changed, and for this reason only 405 is changed under the recommendation No. 3 for the approval of the Association.

Mr. Lindsay:—I do not understand that it will be necessary to change the definition of a broken rail, which reads, "this term to be confined to a rail which is broken through, separating into two or more parts. A crack which *might* result in a complete break will come under this head." But in consultation with an officer of the Public Service Commission of the

State of New York on this subject, the definition of a broken rail, for the purposes of report to the State, was determined as follows:

"For the purposes of this yearly report, a rail shall be considered as having broken when complete fracture into two or more parts has taken place, when there is any break in the head of the rail on the gage side, or when there is any other break necessitating either the immediate removal of the rail from the track, or its reinforcement."

The latter definition will reduce the number of rails reported as "broken," and the word "might" in the former definition is indefinite.

Mr. Churchill:—There is very little difference in the meaning of the two wordings. Rail will not come out of the track, or will not be reported as broken rail unless it is in such shape that it must be reinforced or taken out. If it is cracked to such extent as to require reinforcing, it is proper to call it a broken rail.

Mr. Lindsay:—The only thing to be accomplished by the definition I have read is that it reduces the number of "broken" rails reported to the civil authorities.

Mr. W. C. Cushing (Pennsylvania Lines):—The classification as adopted by the Rail Committee is based on the common classification generally given by the men who see the failures in service. The person reporting them knows nothing about internal defects or anything of that sort. They describe them as they are spoken of colloquially. The information for the broken rail classification of the Public Service Commission can be given from these reports by adding together several classifications given by the Committee. The Public Service Commission broken rail term is not quite sufficiently sub-divided for our purpose, and we gave careful consideration to Mr. Lindsay's suggestion in regard to the matter when he brought it before the Committee in writing. It was considered that it was not advisable to make any change in the classification that had already been put in service by a large number of railway companies.

The President:—If there is no further discussion, the Committee's conclusion will be adopted. The next is conclusion 4.

Mr. Churchill:—"4. That the drawing showing 'Standard Locations of Borings for Chemical Analyses and of Tensile Test Pieces' be adopted and included in the Manual."

We find that railways have been examining rails in different ways. The results of such examinations are that uniformity is not secured, sometimes not only in results, but in conclusions. This matter has been discussed with the chairman of the Manufacturers' Committee, and he is in accord with us—that this general plan of taking borings for chemical analysis at the upper corner, and the lower part of the head, with a third one at the base of the flange is correct, for determining the character of the metal, for determining segregation, and finding out therefrom what is the trouble in case of a rail failure; and for the same reason, tensile tests should be made at the same points for getting information as to the character of the steel. It is with the idea of seeking uniformity of practice by all railways and manufacturers, so that results can be accurately compared and proper conclusions reached, that this is recommended.

Mr. Lindsay:—On the screen last night we saw a section of an ingot showing the way segregation takes place. I would like to ask the Committee if that segregation is reasonably symmetrical around the vertical axis, and does that bring the poorest metal in the web of the last rail made from that ingot?

Mr. M. H. Wickhorst (Engineer of Tests, Rail Committee):—Yes, it is approximately so.

Mr. Churchill:—The general method of making rails brings the center of segregation or defective material near the junction of the head and the web. It, of course, extends down through the web and into the flange, but the web is so thick that if one attempts to take borings from it he will secure mixed good and bad material. For this reason, if for no other, the best location for a segregation test is near the base of the head, where the material is most often irregular, in a questionable rail.

The President:—If there is no further discussion on conclusion 4, the Committee's recommendation will be adopted. We will now take up conclusion 5.

Mr. Churchill:—"5. That the form of tabulating 'Results of Drop Tests and Surface Inspection of Rails' be adopted and included in the Manual."

The methods of railways in keeping a record of the manufacture of rails has not been uniform. Such a record gives very valuable information, not only for the individual roads, but for the individual members of the Association and this Committee. This form of record will become of great importance a few years after the rolling of rails. The form that is shown in this report is M. W. 418, and has been gotten up in such a manner that it makes no difference what specifications are used, for one can place the specification on the bottom of the form. The record of the rolling reported by the inspector can be placed in the proper columns —the quantity of No. 1 and No. 2 rails and the amount rejected, etc., are all given place. The Committee wishes to secure this class of information when possible. It is therefore with a view of uniformity that this form is recommended for adoption.

The President:—The question is before you for discussion. If there is no discussion on this subject, the Committee's recommendation and the form submitted will be adopted.

Mr. Lindsay:—Before the Committee is relieved, I would like to say, in studying our broken rail reports as to causes, I find that a very large percentage of the breaks occur on the left-hand rail, as high as 90 per cent. in some months. In looking further, I have been able to locate some breaks due to defective equipment, and in connection with that, I get reports of flat wheels passing over the road. Following these up, I almost invariably find that the car inspector's reports show that "the wheel was examined before it left the terminal, and the flat spot was within the limits prescribed."

The President:—How do you determine the left-hand rail?

Mr. Lindsay:—The left hand rail in the direction in which the train is running, the fireman's side. I think you will find that is so in almost all cases. I think there is something about the construction of the locomotive that causes this.

The President:—You have reference to double track?

Mr. Lindsay:—Yes. Would it not be possible to have the machine that was shown last night for testing the pressure of wheels on the rail modified so as to put a flat wheel on it, and see the effects of flats of different lengths on the rail—see whether we can break a rail with a flat wheel?

Mr. Wickhorst:—That machine you saw illustrated last night moves at slow speeds, and we could not get the speed effect with it.

As regards Mr. Lindsay's question as to the cause of breakages occurring mostly on the left-hand side, in the Proceedings of the American Society for Testing Materials, 1907, page 124, I presented some discussion on that phase of the matter, and the reason that is given there is that it so happens that when we get the heaviest downward load due to the counterbalance, the engine noses to the left at the same time. Or it may simply be due to the left counterbalance being set 90 degrees behind the right, and thus reinforcing mostly on the left side, the downward effect already produced by the right counterbalance.

Mr. Lindsay:—How about the right-hand counterbalance being down?

Mr. Wickhorst:—The counterbalances are quartered, the left being set 90 degrees behind the right. They cannot ride together, and they are not 180 degrees apart. When you get the greatest downward effect, due to the counterbalance, the engine happens to be nosing to the left-hand side. The discussion in the above-mentioned Proceedings covers several pages, with diagrams.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—Supplementing what Mr. Lindsay said, I would testify that it is a fact known to us that during certain months of the winter 100 per cent. of the broken rails occurred on the left-hand side of the track. The uniform method of reporting rail failures has developed certain facts, and the system of reports now in use is so complete that we have before us this data, and during several months of the past winter all of the breaks, practically speaking, on the road with which I am connected, occurred on the left-hand side.

Mr. Churchill:—You are speaking of what must be classed as broken rails under the definition?

Mr. Wendt:—I am speaking strictly of broken rails, rails actually broken and removed promptly, and it is a significant fact—and this fact has raised a good many questions in the minds of all. I am glad to hear some explanation of it, because when the causes are unknown, we naturally jump to the conclusion that defective equipment is going over the road. Mr. Wickhorst says that, theoretically speaking, breaks naturally would occur on the left-hand side. It does not seem to me that the literature on the subject is very extensive, and the point has never been very clearly brought out, so that it is a field for further research, and the results of this research will ease the minds of those connected with roads where such danger is found, and it may help to clear up a situation that is peculiar.

Mr. Wickhorst:—I would like to remark further that the preponderance of broken rails on the left-hand side applies probably to what you would call cross-sectional breaks or base breaks. It does not seem to apply so much to longitudinal breaks, split heads, for instance.

Mr. W. H. Elliott (New York Central & Hudson River):—The data in regard to the weight of a wheel on the rail for the various points of counterbalance of a wheel of a locomotive were worked out in 1892, and appears in the Proceedings of the Master Mechanics' Association for that year. It was then shown, as I recall it, that the left forward driver of an American locomotive running at 60 miles per hour was the heaviest on the rail of the four driving wheels, for certain positions of the counterbalance, but there did not appear to be the difference in the weight on the rail to account for such a great difference as has been described in the breakages between the left and right-hand rail.

I would suggest that this matter be taken up with the Master Mechanics' Association by our Committee, and the weight on the rails of each of the drivers of a Pacific type engine be determined for a speed of about 60 miles per hour, and for each 10 degrees of the circumference of the wheel for those points where the counterbalance is below the center of the axle. This matter, I believe was very fully considered by that Association in connection with the wear of tires in the endeavor to account for certain driving wheels wearing more at a point between the crank position and the counterbalance. This point is not directly opposite the counterbalance, but a little ahead of it.

Mr. R. G. Kenly (Minneapolis & St. Louis):—I ask, as a matter of information—are these breaks found on single track to occur on the left-hand rail as frequently as in the right-hand rail?

Mr. Wickhorst:—I might answer, yes, even as to that if we consider the direction of maximum speed as on grades or the foot of grades.

Mr. Kenly:—The thought occurred to me that probably the broken rails on the double track results from loose, or relatively loose track, on the inside rail, due to the fact that the track is not so well drained at the middle between the double tracks as it is on the outside, and that probably the number of loose ties or loose heads in the inside rail on the double track is more the cause of the broken rails than is the thrust or impact of the engine on the left-hand side. I do not know whether we have any information to show there is more bad surface on the inside rail than on the outside rail, but it occurs to me that is where you will find your cause for broken rails in the case of double tracks.

Mr. Lindsay:—The track of which I speak is a four-track system, stone ballasted, nine inches or more under the tie. It may be loose and badly drained, but we have not been able to detect its influence in breaking rails.

Mr. R. N. Begien (Baltimore & Ohio) :—This is a matter which we now have under consideration. We have noticed, on our Chicago Division, that practically 90 per cent. of breakages in the rails occurred on the left-hand side, and about two months ago the matter was referred to the Motive Power Department to see what effect the engine had on the track in question. The Motive Power Department has not yet given us a report of the matter. I consider it a very important subject, because if practically all the breaks are going to occur on the left-hand side, some remedy may be applied. Perhaps this suggestion is a little radical, but possibly the use of a heavier rail on the left-hand side might be better.

The President:—The Committee suggest that is a matter for investigation by the Committee on Track. Is there any further discussion? If not, we will proceed to the other part of the Committee's report.

Mr. Churchill:—The second and third questions given to the Committee are answered on the tabulated statistics of rail failures, for the six months ending October 31, 1909, published in Bulletin 121. That report, although published last year in preliminary form, has been corrected and added to, so that it is now in very complete shape, and it will form the basis for future comparison. The corresponding report for October 31, 1910, is now being tabulated. The next report of this character will be an extremely important report, for the reason that many roads are using rails of the later sections, the records of the rolling of which have been more completely and carefully kept than heretofore, and they are using rails that were manufactured at a period when we are assured the manufacturers were and are using effort to secure the desired result, hence we hope that we will obtain information carefully tabulated as of October 31, 1911.

Instruction No. 4 asks the Committee to present reports on the results of tests made in conjunction with the Manufacturers' Committee. Mr. Wickhorst has had this in hand, and his reports are compiled in the general appendix. They are very complete as far as we have gone. We feel that this work is not destructive in any sense of the word—it is constructive. We are getting the benefit of this work; and manufacturers are getting the benefit of it, as well as the users of rails. I heard a remark this morning that was made by a rail inspector to another party and given to me. It was to this effect: "I do not know what the work of this Committee in all its details is going to lead up to; but I know one thing, and that is, the rails that are being turned out to-day are better than they were." We believe the manufacturers are working for better rails, and we think the information we are collecting in connection with the Manufacturers' Committee is going to enable them to make better rails at probably some saving. This study is a joint affair, and as long as it is carried on as such, we are certain to secure beneficial results. These good results are going to come through the eternal vigilance on the part of everybody. The manufacturers will use vigilance, I am sure, as the outcome of this joint investigaton, the tabulation of this class of information and the work of Mr. Wickhorst. The improvement will come in a regular, gradual manner. The fact that a certain mill in this country a few years ago was turning out material that was criticized, and to-day is turning out some of the best material, is in itself sufficient proof of my statement. If one mill can accomplish this, others can now make a like product.

We state, in the matter of specifications, we are somewhat in the same position we were a year ago. We have not gotten much closer. Differences then were not very great, and we expect during this year to reach a conclusion with the Manufacturers' Committee.

As to the matter of rail sections, two sections were turned over to us for examination—two A. R. A. sections as compared with other sections in use. We cannot determine at this date, with so few rails of the newer sections in use for such a short time, which are better; or if either of the two are better than others; but these reports that are coming in and will come in during this year, and the additional investigation by Mr. Wickhorst and by others interested, will help us this year towards a conclusion of this question.

The tests of rail joints, under instruction 7, were reported in Bulletin 123. These tests are to be regarded only as a progress report. Unfortunately, the chemical analyses were not thought of at the beginning as being so important as was developed after the tests were completed. The discovery of the great range of chemistry in the angle bars or joints under test was a surprise to us, and we ask for more time on that subject on that account.

As to the standard drilling for rails, referred to in the eighth paragraph of the instructions, we have not taken that up this year; we want to carry on that work later.

The miscellaneous information in the appendix is quite voluminous, and I do not know that I should go into the details. It speaks for itself. We are going to continue the collection of this class of information, but it is hardly of a character that can be discussed on the floor unless someone wants to ask questions about it, and then we will give the best information we can; but the main point has been to obtain correct information. We have gone into the matter of detailed analyses and tests to see why rails break. The specification analysis is not always of much value. We want to know what the characteristics of the rail itself are, and our investigations have been made on these lines, so that we shall not draw any erroneous conclusions.

Mr. McDonald:—In the matter of the testing of the rail joint, I have heard it stated by representatives of prominent manufacturers that some of the joints submitted had been specially prepared for that test and that others had not. I think in order to avoid complaint of that kind it would be well in future for the Committee to select their samples from the general run rather than have any special samples prepared for them.

Mr. Churchill:—I think in every instance the joints were taken from stock. There was possibly one instance of a joint that came from a manufacturer. They were taken at random from my road, and I know that several other roads followed the same course. Unfortunately, some specifications for joints have not been very carefully made up in the past. If our report points to anything, it points to the importance of looking out more carefully for the character of the steel used in rail joints, whoever makes the joint.

Mr. McDonald:—I simply want to emphasize the importance of selecting for tests those materials which we are likely to get in the general run of things rather than to have them particularly selected by people who are interested in the outcome. I realize that it is unnecessary to call the attention of our very intelligent Committee to that matter.

Mr. Churchill:—I move that the conclusions be adopted.

(The motion carried.)

The President:—If there is no further discussion the Committee will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE VIII.—ON MASONRY.

(Bulletin 130.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Masonry has held meetings during the year as follows:

September 17, at Chicago; present: Messrs. W. H. Petersen, Chairman; Geo. H. Tinker, Vice-Chairman; A. N. Talbot, Richard L. Humphrey, G. H. Scribner, Jr., T. L. Condron.

October 29, at Chicago; present: Messrs. W. H. Petersen, Chairman; Geo. H. Tinker, Vice-Chairman; L. N. Edwards, T. L. Condron, Job Tuthill, G. H. Scribner, Jr., A. N. Talbot, Richard L. Humphrey.

November 26, at Chicago; present: Messrs. W. H. Petersen, Chairman; Geo. H. Tinker, Vice-Chairman; L. N. Edwards, T. L. Condron, C. W. Boynton, Job Tuthill, G. H. Scribner, Jr., A. N. Talbot, Richard L. Humphrey.

The following Sub-Committees were appointed early in the year:

Sub-Committee "A"—Revision of Manual:

Richard L. Humphrey, Chairman;
A. H. Griffith,
G. H. Scribner, Jr.

Sub-Committee "B"—Waterproofing of Masonry, Covering Methods, Results, Cost and Recommended Practice:

Geo. H. Tinker, Chairman;
L. N. Edwards,
W. J. Backes,
F. E. Schall,
F. L. Thompson.

Sub-Committee "C"—Define Monolithic Construction; Revise Report on Durability of All Monolithic Construction in Arches or Large Abutments with Wing Walls:

W. H. Petersen, Chairman;
C. W. Boynton,
Job Tuthill.

Sub-Committee "D"—Typical Plans of Retaining Walls and Abutments, Plain and Reinforced, with Comparison and Recommended Practice:

T. L. Condron, Chairman;
W. W. Colpitts,
B. Douglas,
R. T. McMaster.

Sub-Committee "E"—Investigation and Report on the Use of Reinforced Concrete Trestles, Typical Designs and Cost:

A. N. Talbot, Chairman;
C. H. Moore,
G. J. Bell.

Sub-Committee "F"—Recommendations for Next Year's Work:

Entire Committee.

Sub-Committee to Co-operate with the Joint Committee on Standard Specifications for Cement:

Howard G. Kelley, Chairman;
C. W. Boynton,
C. H. Moore.

The following members were appointed a Sub-Committee to co-operate with the Joint Committee on Concrete and Reinforced Concrete:

C. W. Boynton,
L. N. Edwards,
A. H. Griffith,
F. E. Schall,
G. H. Scribner, Jr.,
F. L. Thompson,
Job Tuthill.

REVISION OF MANUAL.

Your Committee recommends that the following changes be made in the Manual of Recommended Practice:

DEFINITIONS.

CEMENT.—A material of one of the three classes, Portland, Natural and Puzzolan, possessing the property of hardening into a solid mass when mixed with water.

PUZZOLAN CEMENT, AS MADE IN NORTH AMERICA.—An intimate mixture obtained by finely pulverizing together granulated basic blast furnace slag and slacked lime.

GROUT.—A mortar of liquid consistency which can easily be poured.

MORTAR.—A mixture of fine aggregate, cement or lime and water used to bind together the materials of concrete, stone or brick in masonry or to cover the surface of the same.

SPECIFICATIONS FOR STONE MASONRY.

3. Stone shall be of the kinds designated and shall be hard and durable, of approved quality and shape, free from seams, or other imperfections. Unseasoned stone shall not be used where liable to injury by frost.

6. Stone shall be dressed for laying on the natural bed. In all cases the bed shall be not less than the rise.

9. Mortar shall be mixed in a suitable box, or in a machine mixer, preferably of the batch type, and shall be kept free from foreign matter. The size of the batch and the proportions and the consistency shall be as directed by the engineer.

When mixed by hand the sand and cement shall be mixed dry, the requisite amount of water then added and the mixing continued until the cement is uniformly distributed and the mass is uniform in color and homogeneous.

SPECIFICATIONS FOR PLAIN AND REINFORCED CONCRETE.

2. Fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, and passing when dry a screen having ¼-in. diameter holes; it shall preferably be of hard siliceous material, clean, free from dust, soft particles, vegetable loam or other deleterious matter, and not more than 6 per cent. shall pass a sieve having 100 meshes per linear inch.

3. The fine aggregate shall be of such quality that mortar composed of one part Portland cement and three parts fine aggregate by weight when made into briquettes shall show a tensile strength at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand.*

4. Coarse aggregate shall consist of material such as crushed stone or gravel which is retained on a screen having ¼-in. diameter holes and having gradation of sizes from the smallest to the largest particles; it shall be clean, hard, durable and free from all deleterious matter. Aggregates containing dust, soft or elongated particles shall not be used.

33. Concrete after the completion of the mixing shall be handled rapidly to the place of final deposit, and under no circumstances shall concrete be used that has partially set before final placing.

35. In depositing concrete under water, special care shall be exercised to prevent the cement from floating away and to prevent the formation of laitance.

36. Before depositing concrete the forms shall be thoroughly wetted (except in freezing weather) or oiled, and the space to be occupied by the concrete cleared of debris.

39. Concrete shall not be mixed or deposited at a freezing temperature, unless special precautions, approved by the engineer, are taken to avoid the use of materials covered with ice crystals or containing frost and to provide means to prevent the concrete from freezing.

RECOMMENDED PRACTICE FOR DESIGNING REINFORCED CONCRETE STRUCTURES.

8. (New.) Shrinkage and temperature reinforcement: Reinforcement for shrinkage or temperature stresses, in amount generally not less than one-third of 1 per cent., and of a form which will develop a high

*This sand may be obtained from the Ottawa Silica Company at a cost of 2 cents per pound f. o. b. cars Ottawa, Ill.

bond resistance, should be placed and be well distributed near the exposed surface of the concrete.

9. Old 8 renumbered. It is recommended that the provisions of the latest report of the Committee on Uniform Tests of Cement of the American Society of Civil Engineers be incorporated in the revised Manual.

WATERPROOFING OF MASONRY.

Pursuant to instructions from the Board of Direction, the investigation of the waterproofing of masonry has been continued during the past year. A Sub-Committee to continue the work of the previous year was appointed early in the season and a circular requesting information sent to the members of the Association. This circular was substantially a duplicate of Circular 122, issued at the request of the Committee in 1909. Circular 122 was published in Bulletin 119.

The Bibliography of Waterproofing prepared in 1909 has been extended and is presented as part of this report; it will be published in the Proceedings for 1911.

The circular issued this year, in addition to the questions asked in Circular 122, requested data as to the lasting qualities of felt. No information was received in reply to this question.

Fifty replies were received, of which 27 contain no information. Some of the replies contain detailed descriptions of many structures. An abstract of all replies containing pertinent information is presented with this report. These, together with the replies received last year, abstracts of which are published in Bulletin 119, are summarized in Table 1, and an analysis of this summary follows in Table 2. The totals in Table 2 are not the same as in Table 1, because some replies contain details of several bridges and some descriptions lack detail enough to permit their use in an analysis.

The last column in Table 1 contains certain information as to cost. The 1909 replies included very little information upon this subject. It was thought that its publication might lead to unwarranted conclusions. More replies have been received this year, but the conditions are so widely different that hardly any two replies cover the same conditions. Under these circumstances an average cost for any one type of waterproofing would likely be far from the true cost. It is also evident that several of the figures are erroneous, sq. ft. and sq. yd. having been confused. Each figure should be considered in connection with the particular example to which it refers. The numbers in the first column of Table 1 refer to the corresponding numbers preceding the abstracts of replies. The abstracts in Bulletin 119 should be numbered 1 to 20.

The masonry structures usually waterproofed are the floors of solid-floor bridges and arches over city streets, to prevent the leakage of ballast water; roofs and walls of subways, to prevent the leakage of ground water; basement and building walls, concrete roofs of buildings and retaining walls, to prevent the leakage of rain or ground water; reservoir and tank walls, to prevent loss by leakage.

The subject of waterproofing may be considered from two points of view. It may be an investigation as to the imperviousness of various substances or it may be an investigation of the methods of treating certain masonry structures so as to prevent the leakage of water through them. The first is a laboratory problem and has not been touched by the Committee. The second is a practical problem and is the one considered by the Committee. There is involved, in a report upon the condition of a structure from this point of view, the element of suitability to use and also the personal equation of the person making the examination. A reservoir wall may be permitted to leak a few gallons daily; a bridge floor must not allow water to drip; in some situations a stain or discoloration would be objectionable and must not be allowed. Different observers might report compliance with any of these conditions as "perfectly satisfactory." In comparing different methods of waterproofing this element must be eliminated. This has been kept in mind in making the analysis in Table 2.

The items in Table 2 have been grouped in four general classes, according to the method of waterproofing employed. Class I has been designated as "Exterior Envelopes." This includes all those processes of waterproofing by which the masonry is covered with a thick coating of more or less impervious material, generally applied in several layers and generally including tarred felt or similar fabric or burlap. The waterproofing materials used are coal tar pitch, asphalt or bituminous products of petroleum. The felt is laid in overlapping layers with a coating of the waterproofing compound between the layers. The whole is then protected from abrasion by a layer of sand, mortar or brick. Sometimes the masonry is first swabbed with the compound, causing the felt to adhere, and sometimes not. It has been supposed that where the fabric is bonded to the masonry it cracks from expansion and contraction more readily than where it is not so bonded. The reports do not indicate whether or not this is true. Whatever material is used for the exterior covering must have considerable elasticity and strength to resist the effects of continual expansion and contraction of the masonry. Burlap has been used in some instances and some felts have been prepared with a canvas back.

The items of Class I have been grouped under four subheads, "a," "b," "c" and "d;" "a" includes all examples of the use of felt and coal-tar pitch; "b," felt and asphalt; "c," burlap and either pitch or asphalt; "d," mastic. Mastic is a bituminous material mixed with sand and applied in one or more thick layers, generally without the use of fabric. Under each subhead are shown the number of separate layers of fabric, as two-ply, three-ply, etc. In Table 3 the items in "a," "b" and "c" have been grouped according to the number of layers of fabric.

Under Class II have been grouped all examples of materials mixed with concrete. This includes liquids or powders sold under various trade names. The Committee is not advised as to the nature of these compounds, and from the few examples reported no conclusion can be drawn.

Class III has been designated "Exterior Coatings" and includes all those coatings of the nature of washes or paints. Some of these coatings are heavy, but differ from Class I in thickness and in being used without fabric.

Class IV includes those examples in which no waterproofing material was used. The number reported is too few to warrant any conclusion.

A study and analysis of the replies by the Committee indicate:

(1) No method of waterproofing has proved entirely satisfactory.

(2) Some cases are reported in each class showing no leaks.

(3) The difference in efficiency between the various classes does not appear to be great. It does not appear to what extent success is due to the quality of the masonry.

(4) Failures are due to faulty details, poor workmanship, poor materials and the formation of cracks in the masonry.

(5) To secure dry work, it is necessary that details should be carefully designed; this includes the details of the masonry as well as of the waterproofing. The materials must be carefully placed by skilled workmen. The supervision must be constant and efficient. Shrinkage and temperature cracks should be prevented by reinforcement.

(6) Concrete masonry designed and placed as above indicated, with properly designed temperature and shrinkage reinforcement, may be made waterproof without the addition of special waterproofing materials.

(21) CENTRAL RAILROAD OF NEW JERSEY.

Bridge No. 29¾. Central Division. Passenger subway at Elizabeth, N. J. Stone and brick arch 8 ft. span, 69 ft. long, lined with white enameled faced brick. Built 1893. Waterproofed originally with tar paper and coal-tar pitch. Roof and sidewalls leaked badly and white face of brick had scaled in many places. The roof and sidewalls were uncovered in December, 1904, and the waterproofing was found badly cracked and worthless.

Back drains were then installed and the exterior surfaces of roof and sidewalls were waterproofed with four layers of felt cemented together with an asphaltic compound (Hydrex Felt and Compound). The waterproofing was then protected from puncture by one inch of cement mortar. The faced brick lining was replaced with salmon-colored brick. Results: No leaks.

Bridge No. 60½. Central Division. Passenger subway at Plainfield, N. J. Reinforced concrete arch 8 ft. span, length about 100 ft. Built in 1901 and waterproofed with "Antihydrine Damp Proofing."

Roof and sidewalls leaked badly and interior surface was badly discolored. In 1907 the roof and sidewalls were uncovered and the structure was treated in the same manner as Bridge 29¾, but the waterproofing was protected by brick laid flat. Results: Walls of subway dried out and no leaks have since appeared.

Bridge No. 42, N. J. Southern Division, near Red Bank. Single track, reinforced concrete culvert over creek, 12 ft. span. Waterproofed with one coat "Cerion Paint" and ½ in. of asphalt. Results: No leaks or discolorations have appeared.

TABLE 1—SUMMARY OF REPLIES

No.	Character of Structure	Materials Used	Results	Costs
1, 2	Roof of Car Barns	Reinforced against shrinkage	8 leaks in 3 acres; 3 years	
3	Roof and Walls of Subway	Walls, reinforced against shrinkage.	No leaks except at bad joints; 5 years	
		Roof, rock asphalt mastic	No leaks; 5 years	
		Bad work repaired with Wunner's bitumen emulsion	No leaks	
5	Culvert Tops	Medusa compound and truss-con	No leaks; 1 year	
6	Brick Wall	Mortar mixed with soap and alum.	No leaks; 3 years	
7	Reservoir	Crushed dust	No leaks; 3 years	
8	Reservoir, 4	1 Soap and alum and elaterite	No measurable leakage	Two coats soap and alum 43c. per 100 sq. ft.
		3 Soap and alum and asphalt	No measurable leakage	Asphalt $1.04 per 100 sq. ft.; Elaterite $1.52 per 100 sq. ft.
9	Arches, Retaining Walls, Bridge Floors	5-ply burlap, pitch and asphalt	Good results	
10	Arches, Bridge Floors	2-ply burlap and pitch	No leaks; 3 years	Placed by contractors; approximately 20c. per sq. ft.
11	Roof of Magazine	Rich mortar plastering	Not perfect	
12	Bridge Floor	6-ply felt and pitch	No leaks except along webs of girders	Approximately 6c per sq. ft.
	Bridge Floor	1-2 mortar	Just as good; 2 years	
13	Bridge Floor	Sarco and burlap	Good	About 8c. to 38c. per sq. ft.
14	Bridge Floor	4 or 5-ply felt and pitch or asphalt	Few leaks; 8 bridges, 2 leak, 6 O. K.	About 5c. per sq. ft.; protection over waterproofing about 7½c. per sq. ft
15	Bridge Floor	Sarco and burlap	One leak	15c. per sq. ft.
16	Bridge Floor	Asphalt	Some leaks around rail joints	24c. per sq. ft. including labor and material.
17	Trough Bridge Floor Masonry Arch	5-ply felt and asphalt	Practically water-tight	9.1c. per sq. ft.
		Young's mixture	No leaks	Chemical cost $290.85; Concrete, including chemical cost $10.23 per cu. yd. or 6.3c. per sq. ft.
18	Bridge Floor Concrete Arch	Mastic	9 bridges; 2 tight, few leaks in 7	Natural rock asphalt mastic 45c. per sq. ft.; Hydrex felt with brick 25c. per sq. ft.; positive Seal felt 23c. per sq. ft.; Special asphalt mastic 30c. per sq. ft.
		5-ply felt and asphalt	9 bridges; 2 tight, few leaks in 7	Natural rock asphalt mastic 45c per sq. ft.; Hydrex felt with brick 25c. per sq. ft.; positive Seal felt 23c per sq. ft.; Special asphalt mastic 30c. per sq. ft.

Note—Numbers in the first column refer to the abstracts of replies having the corresponding numbers, which should be read in connection with the table.
* Nos. 1 to 20 refer to abstracts published in Bulletin 119 and in the Proceedings of the 1910 Convention.

TABLE 1—Continued.

No.	Character of Structure	Materials Used	Results	Costs
19	Retaining Walls	Asphalt paint	Can be scraped off	
		Cement and coal tar	Penetrates	
	Bridge Floors	Felt and pitch	Difficult to handle, abandoned	
		Mastic	Cracked, abandoned	
		3-ply burlaps saturated with asphalt	Good results, expensive	
		3-ply plain burlap, asphalt and mastic	Few leaks; tore over columns	About 16c. per sq. ft.
20	Masonry Arches with Concrete Backing Cellar Wall	Young's mixture	Leaks	
		Sarco mixture	O. K., 1 year	15c. per sq. ft.; including material, tools and labor.
		Young's mixture	Failed } N. B.—Conditions different	
		Winslow's compound	O. K. 18 mos. }	
21	Stone and Brick Arch	Tar paper and pitch	Leaked badly; waterproofing cracked; 1 year	
		4-ply felt and asphalt	No leaks; 4 years	40c. per sq. ft.
	Reinforced Concrete Arch	Anti-bydrine damp-proofing	Leaked badly	
		4-ply felt, asphalt and brick	No leaks; 2 years	31½c. per sq. ft.
	Reinforced Concrete Arch	Cerion paint and ½ inch asphalt	No leaks	
	Reinforced Concrete Arch	Cerion paint and 1 inch asphalt	No leaks; 5 years	10c. per sq. ft.
	Bridge Floor-plate	2-ply felt, 1 burlap and mastic	Leaks along webs of girders	
	Bridge Floor-plate	Hydrex felt	Small leaks over columns; 1 year	
	Bridge Floor-trough	Asphalt concrete and ⅓-inch mastic	No leaks in waterproofing	
22	Cellar	3-ply tar paper and asphalt	No leaks; 3 years	About 6c. per sq. ft.
23	Concrete Wall	3-ply Barrett felt and asphalt	No leaks; 3 months	5.8c. per sq. ft.
24	Subway—Plate Roof	5-ply felt and asphalt; also red lead paste and brick in asphalt on roof	No leaks; 6 years	
25	Basement	6-ply felt and pitch	No leaks; 6 years	5c. per sq. ft. for 3-ply; 10c. per sq. ft. for 6-ply; contract price.
26	Retaining Walls	⅛-inch pitch	Fairly satisfactory	3.18c. per sq. ft.
	Dust Line	3-ply tar paper and pitch	Unsuccessful; expansion causes cracks	5.91c. per sq. ft.
	Subway Walls	4-ply felt and pitch; hollowtile	No leaks	Hollow tile 18.5c.; waterproofing 5c. per sq. ft.; total 23.5c. per sq. ft.
	Roof—Concrete Arches	3-ply felt and pitch brick	No leaks	Waterproofing 3.82c. per sq. ft.; brick protection 9c. per sq. ft.; total 12.82c per sq. ft.
27	Trough Bridge Floor	Iron bark	Failed	
		5-ply Hydrex, 3 tracks	1 dry, 2 leak, 2 years	95c. per sq. yd.
		4-ply Barretts, 2 tracks	1 dry, 1 leaks; 4 years	16½c. per sq. yd.
		Iron bark, 2 tracks	No leaks; 4 years	
		5-ply Hydrex, 1 track	No leaks; 3 years	

TABLE 1—Continued

No.	Character of Structure	Materials Used	Results	Costs
27 Cont'd	Trough Bridge Floor	4-ply Barrett, 1 track	Leaks badly; 3 years	
		Iron bark, 1 track	Failed; 1 year	
		5-ply Hydrex, 1 track	Leaks badly; 2 years	
		5-ply Hydrex, 3 tracks	Leak badly; 3 years	
		4-ply Barrett, 1 track	Leaks badly; 3 years	
		Iron bark, 1 track	Failed; 1 year	
		5-ply Hydrex, 1 track	Leaks badly; 2 years	
		Iron bark, 5 tracks	Removed, 1 year	
		5-ply Hydrex, 5 tracks	Leak badly; 2 years	
		5-ply Hydrex, 1 track	Leaks badly; 3 years	
		4-ply Hydrex, 1 track	Leaks badly; 3 years	71½c. per sq. yd.
		4-ply Barret, 2 tracks	Leak badly; 3 years	
		3-ply Hydrex, driveway	Leaks badly; 3 years	57c. per sq. yd.
		4-ply Hydrex, 3 tracks	2 dry, 1 leaks; 3 years.	
		4-ply Barrett, 1 track	Leaks badly; 3 years	
		Iron bark, 1 track	Removed; 1 year	
		5-ply Hydrex, 1 track		
		Iron bark, 5 tracks	Removed; 1 year	
		5-ply Hydrex, 5 tracks	Leak badly; 2 years	
		4-ply Hydrex, 3 tracks	Leak badly; 3 years	
		4-ply Barrett, 1 track	Leaks badly; 3 years	
		3-ply Hydrex, driveway	Leaks badly; 3 years	
		6-ply Barrett, 1 track	No leaks; 3 years	24½c. per sq. yd.
		4-ply Barrett, 1 track	Leaks badly; 3 years	
		4-ply Hydrex, 2 tracks	Leak badly; 3 years	
		Iron bark, 1 track	Removed; 1 year	
		5-ply Hydrex, 1 track	Removed, 1 year	
		Iron bark, 5 tracks	Removed; 1 year	
		5-ply Hydrex, 5 tracks	2 dry, 2 leak, 1 leaks badly; 2 years	
		4-ply Hydrex, 2 tracks	1 dry, 1 leaks	
		4-ply Barret, 2 tracks	No leaks	
		6-ply Barrett, 1 track	No leaks; 3 years	
		4-ply Hydrex, 2 tracks	1 dry, 1 leaks badly; 3 years	
		Iron bark, 2 tracks	Removed; 1 year	
		5-ply Hydrex, 2 tracks	1 dry, 1 leaks	
		6-ply Barretts, brick protection	No leaks; 1 month	13.2c. per sq. ft.
		5-ply Hydrex,	1 leak; 1 year	95c. per sq. yd. including material, tools and labor.
28	Plate Floor	Pitch	Leaks through boltholes	
	Train Shed Floor	Mastic	Cracked and leaks	

TABLE 1—Continued.

No.	Character of Structure	Materials Used	Results	Costs
29	Concrete Slab; Bridge Floor	5-ply felt, 1 burlap and pitch	No leaks; 15 months	15½c. per sq. ft. including 10 yr. guaranty
31	Floor Slabs	3-ply burlap, Sarco		Floor slabs, L. 7.7c.; M. 12.5c. per sq. ft. back of walls, L. 1.0c.; M. 1.0c. per sq. ft.
32	Floor Slabs	Mortar, pitch	No leaks	Between 40c. and 50c. per sq. ft.
33	Floor Slabs	Felt and pitch	Small leaks; 2 years	Maximum cost about 30c. per sq. ft.
34	Block and Tile Wall	Elaterite	Cracked and curled up; 1 year	M. $1.00, L. 10c. per 100 sq. ft.
		Bay State cement coating	Wore off; 1 year	M. $2.60, L. 30c. per 100 sq. ft.
		Coal tar and cement		M. 10c., L. 10c. per 100 sq. ft.
35	Bridge Floors	Asphalt mastic	Leaks along girders; mastic cracks	15½c. per sq. ft. in place.
36	Masonry arch	Asphalt	Prolonged life 10 years	15c. per sq. ft. including removal of fill and supporting of tracks during work.
37	Subway	Asphalt, felt, burlap, Sarco, brick	Bottom and sides, 1 leak per 100 sq. ft.	13c. per sq. yd. including brick encasing.
		Hydrolithic cement	Roof leaks a little; 2 years	
38	Cellar	5-ply Barret's	No leaks; 1 year	About 12c. per sq. ft. labor and material.
39	Bridge Floors	Felt	No leaks	
		Mastic	3 out of 7 bridges show leaks along girders	
41	Reservoir	Asphalt	Good results	
43	Bridge Floor	4-ply felt and slag on matched flooring	Many leaks	About 8c. per sq. ft. for felt and slag only; done under traffic.
45	Bridge Floor	Barret's	No leaks; 4 months	
46	Reservoir	Medusa	Reduced leakage; 1 month	15c. per sq. yd.
47	Bridge Floors	Pitch on matched flooring	Failed after about 5 years	
		4-ply burlap and elaterite on creosoted plank	Failed second winter	60c. per sq. ft.
48	Bridge Floors	1-ply burlap and sarco	4 bridges, no leaks; one bridge leaks slightly; 1 year	11.4c. per sq. ft.

TABLE 2.

	No Leaks.	Leaks Slightly.	Leaks Badly.	Total.
I. Exterior Envelopes.				
(a) Felt and Pitch.				
2-ply	1			1
3-ply	1		1	2
4-ply	4	1	7	12
5-ply	4			4
6-ply	3	1		4
Total	13	2	8	23
(b) Felt and Asphalt.				
3-ply	2	1	2	5
4-ply	6	3	8	17
5-ply	8	5	20	33
Total	16	9	30	55
(c) Burlap and Pitch or Asphalt.				
1-ply	5	3		8
4-ply			4	4
5-ply		1		1
Total	5	4	4	13
(d) Mastic	1	2	2	5
Total, Class I.	31	16	44	91
II. Substances Mixed with Concrete	5	1	2	8
III. Exterior Coatings	6	9	27	42
IV. No Waterproofing Material	1	3		4
Total Examples	43	29	73	145

TABLE 3.

1—a, b, c.				
1-ply	5	3		8
2-ply	1			1
3-ply	3	1	3	7
4-ply	10	4	19	33
5-ply	12	6	20	38
6-ply	3	1		4

Bridge No. 49. L. & S. Division. Bowmans, Pa. Double-track, reinforced concrete culvert over creek, 13-ft. span. Roof waterproofed three coats of "Cerion Paint" covered with 1 in. of cement mortar. Built October, 1904. Results: No leaks or discolorations have appeared.

Bridge No. 34. Central Division. Over Grove street, Elizabeth, N. J. Four-track stone ballasted floor, half through plate girder span with I-beam and flat steel plate floor. Length over all, 66 ft. 7 in. Built September, 1907.

Floor waterproofed as follows: Two layers of felt cemented together with asphalt. One layer of burlap stuck solidly to felt with asphalt. The whole covered with ½ in. of rock asphalt mastic. This was carried up the webs of girders about 3 in. on wedge-shaped fillers of tar concrete, the waterproofing being cemented solidly to the webs. Waterproofing was protected by brick laid flat in hot coal-tar pitch and coated with the same. Results: A large number of leaks appeared along the webs of the girders the first winter, due to the separation of the waterproofing from the steel. The brick were removed and the waterproofing carried up under the flashing angle as in Bridge No. 63. Results: The waterproofing is generally satisfactory, but a few small leaks have again appeared along the webs of the girders. Two bridges, or an area of 8,000 sq. ft., were waterproofed in this manner.

Bridge No. 63. Central Division. Over Central avenue, Plainfield, N. J. Four-track, stone ballasted floor, half through plate girder span, with sidewalk columns, I-beams and flat steelplate floor. Waterproofed as per plan No. 6009-D-3, herewith, with Hydrex Felt and Compound. Built June, 1908. Results: No leaks in waterproofing or along the webs of the girders. Small leaks have appeared over the columns between the ends of the main and sidewalk girders, due to the working of the riveted joint by deflection of the girders. These leaks, however, are not through the waterproofed portion of the structure. Thirteen bridges, or 40,000 sq. ft., were waterproofed in the same manner, with like results.

Bridge No. 4½. Manufacturer's Bridge, Passaic avenue, Newark, N. J. Single track half through plate girder span, with I-beam trough floor. Built 1907. Troughs waterproofed as follows:

(1) The floor and sides of troughs to lines of the finished work were painted with best quality asphalt paint, two coats.

(2) In each trough was placed an asphalt concrete composed of two parts rock asphalt, one part refined asphalt, and seven parts stone, the concrete being tamped in place.

(3) The surface was finished ½ in. coat of rich rock asphalt mastic mixed with fine grit and reduced with refined asphalt. Results: No leaks have appeared along the webs of the I-beams or girders. Small leaks not due to defects in the waterproofing have, however, appeared back of the connecting angles along the webs of the girders.

The following is the general practice of this company: "For passenger subways, large arches, or where it is thought necessary to protect the reinforcement from damage from moisture due to possible cracks in the concrete, four layers of felt are used, protected with either brick or cement mortar.

"For small monolithic or reinforced concrete structures not liable to cracks, the exterior surfaces are given three coats of asphaltic or other similar paint, applied cold.

"For stone ballasted floors of steel bridges, the method indicated on plan No. 6009-D-3 is used. No reliance is placed on the adhesion between the steel and waterproofing, as it is found that in cold weather the vibrations cause the edges to separate and curl over, allowing the water to enter.

"For trough floors the type shown on Plan No. 6081-D-4 is used."

(22) NEW YORK, CHICAGO & ST. LOUIS RAILROAD.

1. Basement of Passenger Depot, Hammond, Ind. 2. Head of water, 3 ft. 3. Wooden sheeting lined with asphalt and paper. 6. Perfectly watertight; no leaks. (a) Three years. Should last indefinitely.

7. The pit for the basement was first lined with ⅞-in. wooden sheeting. This sheeting was then swabbed with asphalt, and covered with three-ply tarred paper, each ply being swabbed with asphalt. The concrete walls and floor, 12 in. thick, were placed against the asphalt lining. During the progress of the work the pit was kept free of water by pumping. As soon as the wall reached the level of the ground water, the pumps were stopped and the basement flooded. The concrete was allowed to harden under water for about three weeks.

Up to the present time no leakage whatever has occurred. As the materials are constantly submerged, their life should be indefinite.

(23) OREGON SHORT LINE.

Below are given the items concerning which information was asked in connection with the clubhouse at Montpelier, Idaho, the basement of which we waterproofed.

1. The structure is a three-story clubhouse for railroad employes, first story concrete, two upper stories frame.

2. Conditions requiring waterproofing: The first story is half in the ground and half above. The ground water level is very near the surface, and there was about four feet head over the floor of the basement.

3. The standard Barrett specification for waterproofing basements was used. Amount of material as follows:

8,100 sq. ft. of tarred felt.
6,000 lbs. of asphalt (coal-tar pitch not being on hand).
Total square feet of waterproofing, 2,700.

6. The results obtained have been first class, no leakage at all being apparent at the present time. The work has been in place about three months. Estimated life is indefinite.

7. Remarks: For the general method of this waterproofing. see the Barrett Hand Book, pp. 31-35, inclusive. It will be noticed from the

specifications that the waterproofing is put between two layers of concrete, so that it is entirely protected from being broken in service.

(24, 25) NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

The best example of waterproofing of masonry that has come to our observation has been the subway at the Troy Passenger Station, a copy of the plan of which can be obtained upon application to Mr. Kittredge, and without which the writer is unable to give the answers to the circular questions exactly as asked. The subway has a rectangular opening, two abutment walls, an intermediate line of columns and a plate and I-beam floor. The subway was to be used as an adjunct to the waiting-room, heated and lighted and made comfortable for passengers sitting waiting for trains, so that not only the ordinary seepage, but the fact that the drain was three feet higher than the floor, had to be provided for. The method of construction was as follows:

A layer of concrete, one foot in thickness, was placed wide enough to take the body walls, and eight inches wider on each side to take a brick backing. On top of this footing five thicknesses of single-ply tar paper in hot asphaltum were laid, the paper being left long enough all around to lay up over the body walls. The foundation and body walls were then built on top of this. The backs and tops of the body walls were coated with asphaltum and on top of this five thicknesses of single-ply tar paper with hot asphaltum was applied. On top of this the backs of the body walls were laid with single brick wall in cement mortar. The steel work was then erected; the seams were caulked with chisels, and on the latter seams salammoniac and iron fillings were used. The bridge was then flooded with water and the leaks taken care of. After this a thick paste of red lead and linseed oil was applied, thoroughly filling the cracks. Then two coats of red lead were applied on top of the paste and on top of this a coat of asphaltum was applied, on top of which five thicknesses of tar paper were laid in asphaltum, lapping down over the backs of the abutments so as to make a waterproof joint. On this an inch of cement mortar was spread and then a layer of vitrified paving brick laid in hot asphaltum, filling the joints with a mixture of hot sand and asphaltum. The subway was completely encased by five thicknesses of tar paper in asphaltum, the brick backing, a coat of red lead paste and paint and brick protection being additional precautions. The work was done in the summer of 1903 and, with the exception of one leak where the steam and water pipes enter, there has been absolutely no leak, and it would seem that the waterproofing would last as long as the structure is needed, say 25 years.

1. Character of structure waterproofed: Basement of Port Morris Power Station. Two rooms, one 15 ft. by 240 ft., one 40 ft. by 240 ft., connected by two passages 15 ft. wide.

2. Conditions requiring waterproofing, head of water, etc.: The floor of these rooms is 11 ft. below extreme high tide, and building is situated on water's edge and gets full pressure from this head of water. The water-

proofing is protected and held in place by reinforced concrete floors and concrete sidewalks.

3. Waterproofing consists of alternate layers of felt paper and coal-tar pitch, 6-ply being used for floor and 5 ft. up the sides; above this, 3-ply. Waterproofing has proved effective. (a) Work was done in 1903 and should last indefinitely. (b) Present condition good. (c) Leaks none.

7. Great care was taken to make the concrete surfaces on which waterproofing was placed smooth, and waterproofing was not applied until surfaces were dry. The waterproofing was immediately covered with a coat of plaster to prevent injury in depositing concrete; walking or placing materials on waterproofing was not permitted.

No trouble has developed in this waterproofing, and, upon inquiry, I am told that the basement of the power house is dry.

(26) RETAINING WALLS.

Yonkers.

1. Concrete retaining walls of average height of 15 ft.
2. Wall to be back-filled with porous material and no head of water.
3. Straight run coal-tar pitch swabbed on to a thickness of ⅛ in.
6. Walls have not been back-filled so effectiveness of this particular job cannot be judged, but similar treatment of walls subjected to same conditions has been efficacious.

RETAINING WALLS.

Mott Haven.

1. Concrete retaining walls of average height of 28 ft.
2. No head of water, but ground filled with surface water.
3. Straight run coal-tar pitch swabbed on to a thickness of ⅛ in.
6. The results have been fairly satisfactory.

(a) The walls are two years old.

(b) Present condition good.

(c) A few places where water is seeping through wall where wall is backed against solid rock and where no waterproofing could be placed.

7. On walls at Yonkers and Mott Haven, 1:3:6 concrete was used, and each 50-ft. section of wall was built at one continuous operation, concrete being deposited day and night until entire section was finished, in order to avoid horizontal cleavage lines, which always develop where concreting is stopped before wall is completed.

DUCT LINE WATERPROOFING.

1. Concrete duct lines from Harlem River to 150th street, consisting of two lines of 20 tile ducts incased in 6 in. of class 1:3:6 concrete, with a 12-in. dividing wall between each line.
2. Head of water varies from nothing to four or five feet.

3. Four layers of straight-run coal-tar pitch and three layers of tar paper, lapped 6 in.

6. Waterproofing has not been successful, owing to difficulty of providing for expansion of the long line of ducts, especially where ducts enter splicing chambers.

Plans have been altered and duct lines built without waterproofing, and, where drains cannot be provided to existing sewers from the splicing chambers, automatic electric pumps are installed.

SIDE WALLS OF PARK AVENUE APPROACH TO SUBURBAN STATION.

Grand Central Station.

1. Walls consist of 12-in. and 15-in. I-beams spaced about 3 ft. 8 in. c. to c., and with concrete vertical arches between concrete extending 6 in. back of back flange of I-beams. Walls about 40 ft. high.

2. There is no head of water, but there is considerable surface water percolating through the rocks.

3. The rough faces of rock are smoothed up with 1 in. .7½ concrete, and against this is laid up with 4-in. hollow tile. This tile is then covered with Class A-1 waterproofing composed of four layers of tar felt applied with 6-in. overlap. The main body of 1:2½:5 concrete is then deposited.

6. Results have been satisfactory. The walls have been in about three years and practically no leaks exist.

ROOF OF SUBURBAN STATION.

Grand Central Station.

1. Horizontal concrete arches between I-beams and girders forming a covering for tracks on suburban level and support for tracks on express level.

2. To protect suburban level from water falling on upper level.

3. The roof concrete is covered with Class A-1 waterproofing, consisting of four layers of straight-run coal-tar pitch and three layers of tar felt overlapping 6 in.; vitrified paving brick is then laid in pitch on top of the Class A-1 waterproofing to protect it from abrasion from tamping picks and other track tools.

6, 7. The results have been good. Horizontal drains of cast iron are laid in the ballast in general between every other track from the summits to catch-basins in the valleys. The drains are open on the under side and arch shaped, with bell and spigot ends held together by dowels.

(27) PENNSYLVANIA LINES.

CHICAGO.

The P. C. C. & St. L. Railway tracks on Kinzie street, between Ada and Fulton streets, were elevated during 1904 and 1905, the work requiring the construction of nine subways of widths varying from 5 to 9 tracks.

The bridges are all of solid-floor construction, consisting of rectangular troughs with fascia girders. They are all four-span bridges resting on concrete abutments and three lines of columns, one in the center and one on each curb line. The lengths of these bridges are from 72 ft. 9 in. to 78 ft. 9 in., out to out.

Several schemes for waterproofing were tried, the details of which, together with the results obtained, will be shown for each bridge in the statement given below.

Some trouble was experienced at first with water running over the copings, but the cause was traced to the too solid filling material back of the abutments and a remedy was found in excavating the solid material down to the drain pipes and filling in with cinders.

The bridges referred to are:

Western avenue, 5 tracks.
Oakley avenue, 5 tracks.
Leavitt avenue, 5 tracks.
Hoyne avenue, 9 tracks and 1 driveway.
Robey street, 5 tracks.
Lincoln street, 9 tracks and 1 driveway.
Wood street, 5 tracks.
Paulina street, 9 tracks and 1 driveway.
Ashland street, 5 tracks.

The methods of applying the different types of waterproofing are described below:

Edward Smith & Co.'s Iron Bark.

In this method the troughs were partly filled with concrete, simply to form a gutter to carry the water to the end of the bridge, and a single layer of Iron Bark was put over the span joints only, extending about 2 ft. each side of the joint. The Iron Bark was put in place and pressed as thoroughly as possible against the steel with hot irons. On account of the rivet heads it was impossible to get a perfect job, and the material itself, which is of a fibrous nature, was extremely endurable.

Hydrex Felt and Barrett's Felt.

In this method the troughs were filled with concrete which extended a considerable distance above the tops of the troughs and which was rounded off so as to give a decided pitch from the center of the bridge toward the ends. The concrete was finished smooth and allowed to set well before the application of the felt. Particular care was exercised at the fascia girders in order to have the concrete in close contact with the girder so as to keep any water from running down between them and the concrete. The concrete was carried well up under the top flanges so that the same acted as a water shield. The felt was then laid in various thicknesses, all layers being thoroughly pasted together with the compound, which was applied with a mop. At Hoyne, Lincoln and Paulina streets the concrete was first mopped over with the compound, causing adhesion of the felt. On the other bridges the felt was applied as a loose sheet. In all cases the felt was carried well down over the backs of the abutments and a 2-in. layer of 1 to 3 concrete, made of screenings, was laid on top of the felt to act as a protection against puncture by the ballast. In some cases 6-in. drain tile and 12-in. triangular wooden boxes were imbedded in the concrete to save material. This proved of no value and was discontinued.

Western Avenue Subway.

In 1905, tracks 1, 2 and 5 were waterproofed with Iron Bark, which proved unsatisfactory and was removed in 1907 and replaced with 5-ply Hydrex Felt. In 1905, tracks 3 and 4 were treated with 4-ply Barrett's Felt with 6-in. drain tile in the troughs. In 1909, tracks 1 and 3 showed no leaks, while tracks 2, 4 and 5 showed several leaks.

Oakley Avenue.

Tracks 1 and 2 were waterproofed in 1905 with Iron Bark and in 1909 showed no leaks. Track 3 was treated with 5-ply Hydrex Felt in 1906 and shows no leaks. Track 4 was treated in 1906 with Barrett's Felt, 4-ply, with 6-in. drain tile in the troughs. This track leaks badly. Track 5 was treated in 1906 with Iron Bark, which was removed in 1907 and 5-ply Hydrex Felt substituted for it, but in 1909 this track showed bad leaks.

Leavitt Street.

Tracks 1 and 2, treated with 5-ply Hydrex Felt in 1906, both leak badly. Track 3 was treated with 4-ply Barrett Felt in 1906 and leaks badly. Track 4 was treated with 5-ply Hydrex Felt, with 6-in. drain tile in trough, and leaks badly. Track 5 was treated with Iron Bark in 1906, which was removed in 1907 and replaced with 5-ply Hydrex Felt. This track also leaks badly.

Hoyne Avenue.

Tracks 5, 6, 7, 8 and 9 were treated in 1906 with Iron Bark, which was removed in 1907 and replaced with 5-ply Hydrex Felt. Track 1 was treated in 1906 with 5-ply Hydrex Felt. Tracks 2 and 3 were treated with 4-ply Barrett's Felt in 1906. Track 4 was treated with 4-ply Hydrex Felt in 1906, and had 6-in. drain tiles in the troughs. The driveway was treated with 3-ply Hydrex Felt and imbedded in the concrete were 6-in. drain tile and triangular wooden boxes.

In waterproofing this bridge the surface of the concrete was first mopped with the compound, causing adhesion of the felt to the concrete. It was found in 1909 that all tracks leaked badly.

Robey Street.

Track 1 was treated in 1906 with 4-ply Hydrex Felt with 6-in. drain tiles in the troughs. Track 2 was treated in 1906 with 4-ply Barrett's Felt. Track 3 was treated in 1906 with 4-ply Hydrex Felt. Track 4 was treated in 1906 with 4-ply Hydrex Felt with 6-in. drain tile in the troughs. Track 5 was treated in 1906 with Iron Bark, which was removed in 1907 and replaced by 5-ply Hydrex Felt. In 1909, tracks 1 and 3 showed no leaks; track 2 leaks badly and track 4 shows leaks.

Lincoln Street.

Tracks 5, 6, 7, 8 and 9 were treated in 1906 with Iron Bark, which was removed in 1907 and replaced with 5-ply Hydrex Felt. Tracks 1 and 3 were treated with 4-ply Hydrex Felt in 1906. Track 4 was treated with 4-ply Hydrex Felt in 1906 with 6-in. drain tile in the troughs. Track 2 was treated in 1906 with 4-ply Barrett's Felt. The driveway was waterproofed with 3-ply Hydrex Felt in 1906 and imbedded in the concrete were 6-in. drain tiles and triangular wooden boxes. On the bridge the concrete was mopped with hot compound before laying the felt. In 1909 it was found that all tracks leaked badly.

Wood Street.

Track 1 was treated in 1906 with 6-ply Barrett's Felt and shows no leaks. Tracks 2 and 3 were treated in 1906 with 4-ply Barrett's Felt and 4-ply Hydrex Felt, respectively, and both leak. Track 4 was treated in 1906 with 4-ply Hydrex Felt with 6-in. drain tile in the troughs and now leaks. Track 6 was treated in 1906 with Iron Bark, which was removed in 1907 and replaced with 5-ply Hydrex Felt.

Paulina Street.

Tracks 5, 6, 7, 8 and 9 were treated in 1906 with Iron Bark, which was replaced in 1907 with 5-ply Hydrex Felt. In 1909, tracks 6, 8 and 9 showed some leaks; track 7 leaked badly, and tracks 5 and 6 showed no leaks.

Tracks 1 and 4 were treated in 1906 with 4-ply Hydrex Felt and 6-in. drain tile were imbedded in the concrete under track 4. Track 4 showed leaks, while track 1 did not leak. Tracks 2 and 3 were treated in 1906 with 4-ply Barrett's Felt and in 1909 showed no leaks. On this bridge the concrete was mopped over with a layer of hot compound before laying the felt.

Ashland Avenue.

Track 1 was treated in 1906 with 6-ply Barrett's Felt and in 1909 showed no leaks. Tracks 2 and 3 were treated with 4-ply Hydrex Felt and 2 showed no leaks, while 3 leaked badly. Tracks 4 and 5 were treated in 1906 with Iron Bark, which was in 1907 replaced with 5-ply Hydrex Felt. Track 4 leaks badly.

COLUMBUS, OHIO.

A brief description will be given of the waterproofing of the bridges constructed in 1909, at the crossings of Sandusky and Darby streets with the Cincinnati Division tracks of the P. C. C. & St. L. Railway in Columbus, Ohio.

These bridges are of solid-floor construction, with a floor system composed of rectangular steel troughs placed parallel with the tracks. The troughs rest upon concrete abutments, faced with sandstone, and cross-girders supported by columns at each curb line. The bridge at Sandusky street has a line of girders and row of columns, also, at the center of the street. The parapets consist of reinforced concrete ornamental walls attached to the outside troughs and extending 3 ft. 9 in. above the base of rail.

The Sandusky street bridge has a total clear length of 99 ft., composed of two 18-ft. sidewalk spans and two 31 ft. 6 in. roadway spans. The Darby street bridge has a total clear length of about 50 ft. 6 in., and is made up of two 10 ft. 6 in. sidewalk spans, and one 29 ft. 6 in. roadway span. Both bridges carry four tracks and are approximately 61 ft. 6 in. in width.

The steel troughs were filled to a minimum distance of 2 in. above the top with concrete mixed in the proportion of one part cement, two and one-half parts sand, and three and one-half parts crushed washed gravel. The concrete was finished smooth and sloped so as to form a gutter between each track and at sides of bridge. A summit was put in the concrete at the middle of the bridge to drain the water toward both ends. Tile drains were laid under cinders back of the abutments to carry the water to the sewers. Longitudinal expansion joints were made in concrete under center of each track by placing concrete in alternate sections. Concrete was reinforced over column lines with ¼-in. round rods, 3 ft. in length, spaced 6 in. c. to c., and placed near top surface. The concrete in the ballast walls on top of bridge seat was tied to concrete in troughs by imbedding woven wire mesh near top and bottom surface. Two layers of dry Barrett Felt were placed between the bridge seat back of the bearing plate and the concrete in the ballast wall, to prevent the concrete bonding with stone bridge seat, and thus allow ballast wall to slide freely on the bridge seat with the expansion and contraction of the steel troughs.

The concrete floor was covered with one layer of Barrett Felt, laid dry, in order to prevent adhesion of felt to the concrete. On top of this were placed, alternately, lengthwise and crosswise of the bridge, 5 layers of Barrett Felt. Each layer was coated with hot Barrett pitch applied with dippers. At the abutments the felt was extended over the ballast wall and down the back of the bridge seat. The connection of the waterproofing with the parapet walls at the side of the bridge was made by flashing the felt up against a recess left in the back face of the wall, and afterward completing the parapets by extending concrete from top of the recess over the waterproofing. Special care was taken with this connection in order to avoid the possibility of the water, which comes down the back of the parapet walls, getting under the felt. At Sandusky street it was particularly difficult to secure a good connection on account of the posts in the parapet walls over the columns projecting beyond back fence of wall.

The top layer of felt was well coated with pitch, and then covered with a layer of fine sand about ½ in. in thickness. On top of the sand vitrified brick were laid to protect the felt against puncture by the ballast. The brick were extended over the ends of the bridge down the ballast walls to the offset at the bottom of bridge seat. The brick on the bridge floor were laid dry, so as to have no adhesion between brick and paper. The brick along the vertical back face of the bridge seat and ballast wall were laid in pitch to keep them in place.

Up to December 1, 1909, these bridges showed no signs of leaking. At that time, however, the waterproofing had only been in service about a month, which is, of course, too short a time to give a test of the efficiency or durability of the waterproofing.

It is probable that better results will be obtained at the Darby street bridge than at the Sandusky street bridge, for the following reasons:

(1) Area of Darby street bridge only about one-half that of Sandusky street bridge, hence less water to be taken care of.

(2) Darby street has one less row of columns.

(3) At Darby street the shorter length of bridge and the very shallow troughs in the sidewalk spans made it possible to secure on the surface of the concrete a much steeper slope from center toward ends of bridge than at Sandusky street.

(4) Better connection of waterproofing with parapets secured at Darby street on account of difference in design of parapets.

During the summer of 1908 a bridge was constructed over Marshall boulevard at the P. C. C. & St. L. Railway. This bridge is a single-span four-track bridge, 59 ft. 0 in. between abutments. The abutments are of concrete and the superstructure is of solid-floor construction, consisting of rectangular troughs at right angles to the tracks and supported on the lower flanges of through girders. Z-bars are riveted to the webs of the girders and run their entire length, the purpose of these Z-bars being to prevent water from running down the webs of the girders and getting between them and the concrete.

The waterproofing used at this bridge was 5-ply Hydrex Felt on all four tracks. The method of applying this was as follows: The troughs were filled with concrete, which extended a considerable distance above the tops of the troughs. This bridge is on a 0.4 per cent. grade, and the concrete was rounded off to give the pitch from about 3 feet from the west end toward the east, giving it the natural fall of the bridge. The concrete was finished smooth and allowed to set well before the application of the felt. Particular care was exercised at the girders, in order to have the concrete in close contact with them, so as to keep any water from running down between the girder and the concrete. The concrete was carried well up under the Z-bars, so that the latter acted as a water-shield.

The Hydrex Felt was then laid in five layers, all layers being thoroughly pasted together with the compound, which was applied with a mop. The felt was applied to the concrete as a loose sheet, there being no adhesion between the felt and the concrete. The felt was carried well down over the backs of the abutments and a 2-in. layer of 1 to 3 concrete made of screenings was laid on top of the felt to act as a protection against puncture by the ballast.

An inspection made during the early part of this month shows that one leak has developed in track No. 2, the remainder of the bridge being free from leaks.

(28) CHICAGO, ROCK ISLAND & PACIFIC RAILWAY.

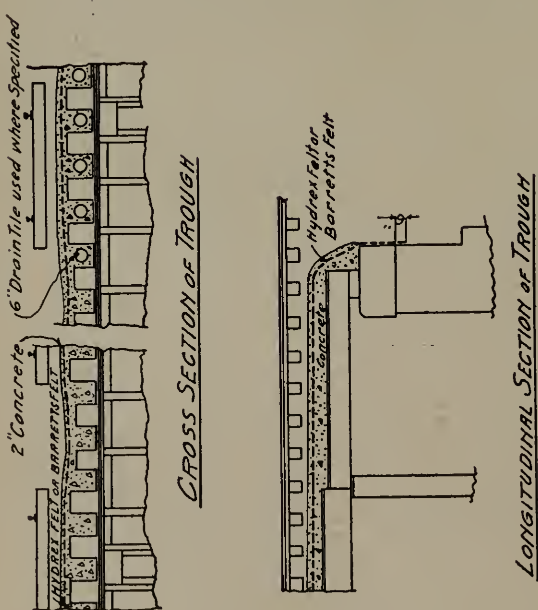
We have done but very little waterproofing on this road, except that about 1899 we put in 40 or 50 subways between Chicago Terminal and

WATERPROOFING BRIDGE FLOORS—METHODS USED AND RESULTS OBTAINED.
Pennsylvania Lines West of Pittsburg, Southwest System.

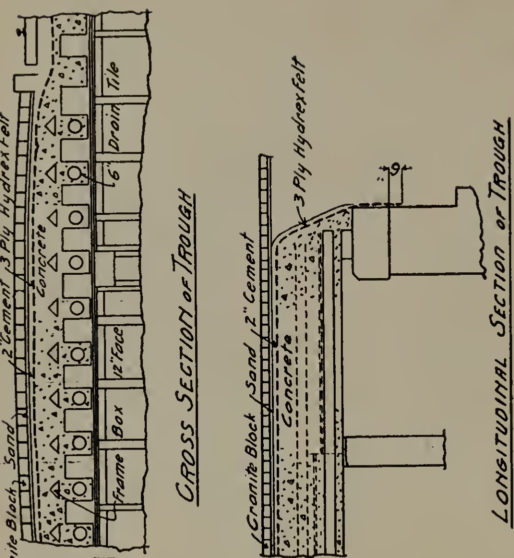
City	Street	Track No.	Method of Waterproofing	Year Applied	Result of Inspection	
					April, 1909	April, 1910
Chicago	Ashland	1	6-ply Barretts Felt Concrete Top	1906	No leaks	No report
		2	4-ply Hydrex Felt Concrete Top	1906	No leaks	No report
		3	4-ply Hydrex Felt Concrete Top	1906	Leaks badly	No report
		4	5-ply Hydrex Felt Concrete Top	1907	Leaks badly	No report
		5	5-ply Hydrex Felt.Concrete Top	1907	No report	No report
	Paulina	1	4-ply Hydrex Felt Concrete Top	1906	No leaks	7 leaks
		2	4-ply Barretts Felt Concrete Top	1906	No leaks	8 leaks
		3	4-ply Barretts Felt Concrete Top	1906	No leaks	No leaks
		4	4-ply Hydrex Felt Concrete Top	1906	6 leaks	15 leaks
		5	5-ply Hydrex Felt Concrete Top	1907	No leaks	No leaks
		6	5-ply Hydrex Felt Concrete Top	1907	No leaks	No leaks
		7	5-ply Hydrex Felt Concrete Top	1907	26 leaks	2 leaks
		Driveway	3-ply Hydrex Felt Concrete Top	1906	No report	No report
		8	5-ply Hydrex Felt Concrete Top	1907	Several leaks	No report
		9	5-ply Hydrex Felt Concrete Top	1907	Several leaks	No leaks
	Wood	1	4-ply Hydrex Felt Concrete Top	1906	No leaks	13 leaks
		2	4-ply Barretts Felt Concrete Top	1906	16 leaks	9 leaks
		3	4-ply Hydrex Felt Concrete Top	1906	4 leaks	No leaks
		4	4-ply Hydrex Felt Concrete Top	1906	Several leaks	No leaks
		5	5-ply Hydrex Felt Concrete Top	1907	No report	No report
	Lincoln	1	4-ply Hydrex Felt Concrete Top	1906	Leaks very badly	4 leaks
		2	4-ply Barretts Felt Concrete Top	1906	Leaks very badly	3 leaks
		3	4-ply Hydrex Felt Concrete Top	1906	Leaks very badly	4 leaks
		4	4-ply Hydrex Felt Concrete Top	1906	Leaks very badly	10 leaks
		5	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No leaks
		6	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No leaks
		7	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No leaks
		Driveway	3-ply Hydrex Felt Concrete Top	1906	Leaks very badly	No report
		8	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	2 leaks
		9	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No report
	Robey	1	4-ply Hydrex Felt Concrete Top	1906	No leaks	15 leaks
		2	4-ply Barretts Felt Concrete Top	1906	No leaks	No leaks
		3	4-ply Hydrex Felt Concrete Top	1906	24 leaks	No leaks
		4	4-ply Hydrex Felt Concrete Top	1906	Several leaks	1 leak
		5	5-ply Hydrex Felt Concrete Top	1907	No report	No report
	Hoyne	1	4-ply Hydrex Felt Concrete Top	1906	Leaks very badly	4 leaks
		2	4-ply Barretts Felt Concrete Top	1906	Leaks very badly	1 leak
		3	4-ply Barretts Felt Concrete Top	1906	Leaks very badly	No leaks
		4	4-ply Hydrex Felt Concrete Top	1906	Leaks very badly	15 leaks
		5	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No leaks
		6	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No leaks
		7	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	8 leaks
		Driveway	3-ply Hydrex Felt Concrete Top	1906	Leaks very badly	No report
		8	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No leaks
		9	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	8 leaks
	Leavitt	1	5-ply Hydrex Felt Concrete Top	1906	Leaks very badly	18 leaks
		2	5-ply Hydrex Felt Concrete Top	1906	Leaks very badly	9 leaks
		3	4-ply Barretts Felt Concrete Top	1906	Leaks very badly	2 leaks
		4	5-ply Hydrex Felt Concrete Top	1906	Leaks very badly	5 leaks
		5	5-ply Hydrex Felt Concrete Top	1907	Leaks very badly	No report
	Oakley	1	Iron Bark Concrete Top	1905	No leaks	No leaks
		2	Iron Bark Concrete Top	1905	No leaks	14 leaks
		3	5-ply Hydrex Felt Concrete Top	1906	No leaks	No leaks
		4	4-ply Barretts Felt Concrete Top	1906	Leaks badly	No leaks
		5	5-ply Hydrex Felt Concrete Top	1907	Leaks badly	No report
	Western	1	5-ply Hydrex Felt Concrete Top	1907	No leaks	5 leaks
		2	5-ply Hydrex Felt Concrete Top	1907	10 leaks	3 leaks
		3	4-ply Barretts Felt Concrete Top	1905	No leaks	No leaks
		4	4-ply Barretts Felt Concrete Top	1905	Several leaks	No leaks
		5	5-ply Hydrex Felt Concrete Top	1907	Several leaks	No report

WATERPROOFING BRIDGE FLOORS—Continued.

City	Street	Track No.	Method of Waterproofing	Year Applied	Result of Inspection	
					April, 1909	April, 1910
Chicago	Marshall	1	5-ply Hydrex Felt Concrete Top	1908	No leaks	No leaks
		2	5-ply Hydrex Felt Concrete Top	1908	No leaks	1 leak
		3	5-ply Hydrex Felt Concrete Top	1908	No leaks	No leaks
		4	5-ply Hydrex Felt Concrete Top	1908	No leaks	No leaks
	34th	1	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		2	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		3	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		4	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
	35th	1	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		2	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		3	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		4	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
	36th	1	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		2	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		3	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
		4	Concrete and Asphalt	1904	Leaks very badly	Leaks very badly
	Archer	1	Concrete—Wire Mesh	1904	No leaks	3 leaks
		2	3-ply Hydrex Felt	1904	No leaks	No leaks
		3	3-ply Hydrex Felt, no Concrete on Top	1904	No leaks	No leaks
		4	Concrete and Asphalt Mastic	1904	No leaks	No leaks
	Western	1	Concrete—No Waterproofing	1905	Leaks very badly	3 leaks
		2	Concrete—No Waterproofing	1905	Leaks very badly	16 leaks
		3	Concrete—No Waterproofing	1905	Leaks very badly	2 leaks
		4	Concrete—No Waterproofing	1905	Leaks very badly	6 leaks
	Normal	1	Asphalt Mastic	1904	No report	15 leaks
	Wallace	1	Asphalt Mastic	1904	No report	No leaks
	Lowe	1	Asphalt Mastic	1904	No report	14 leaks
	Union	1	Asphalt Mastic Blocks	1904	No report	9 leaks
	Emerald	1	Asphalt Mastic Blocks	1904	No report	20 leaks
		2	Asphalt Mastic Blocks	1904	No report	8 leaks
		Side Track	Hydrex Felt	1907	No report	4 leaks
	Halsted	1	Hydrex Felt	1906	No report	1 leak
Columbus	Mill	All Tracks				
	Sandusky		6-ply Barretts Felt, Brick on Top	1909		7 small leaks
	Darby		6-ply Barretts Felt, Brick on Top	1909		1 small leak

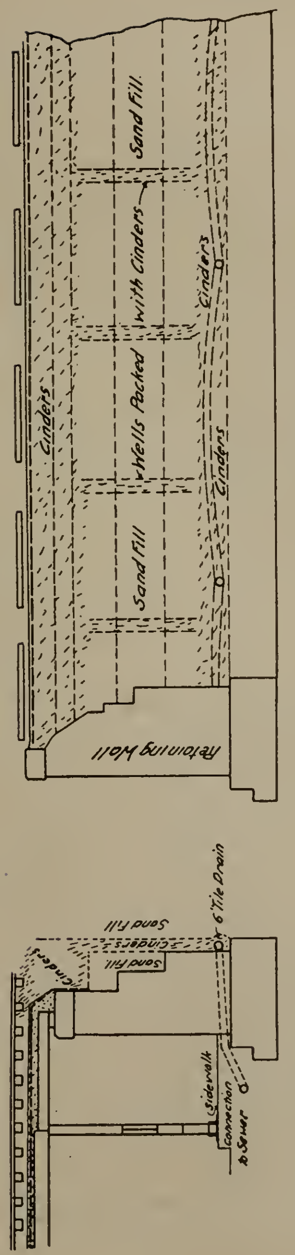


Sketch showing method of applying Hydrex Felt and Barretts Felt on elevated bridges



Sketch showing method of applying Hydrex Felt under drive ways

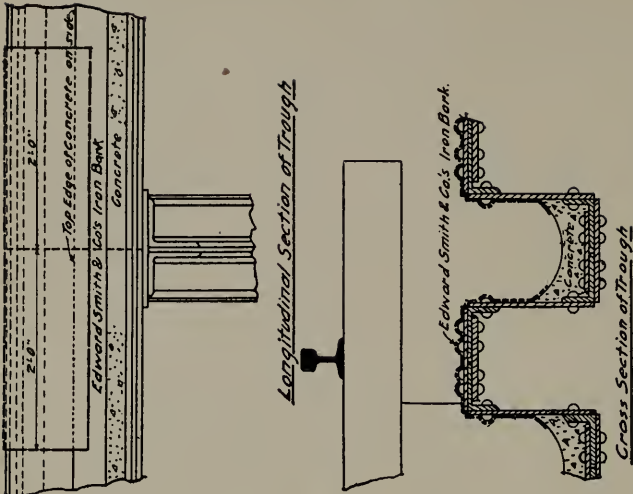
P.C.C.& St.L.Ry.
Chicago Terminal Division
Ada St. to Fulton St.
Office Eng. M. of W. Chicago Ill.
May 29, 1908 Plan No. 2525



Section of Abutment

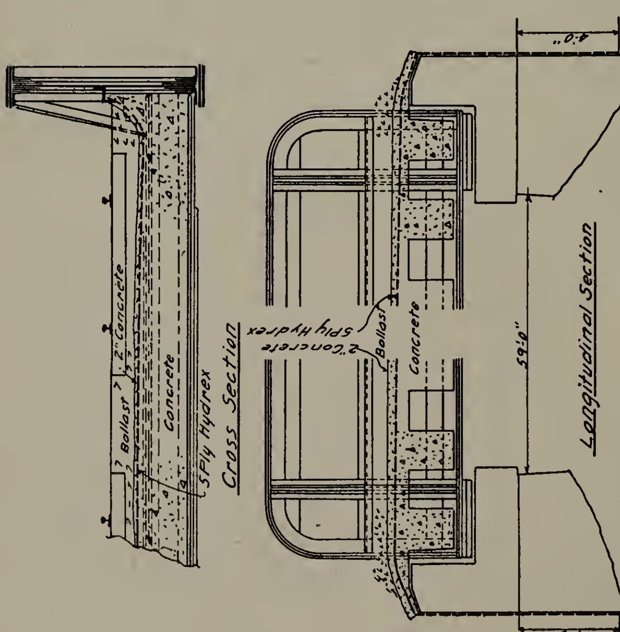
Rear View of Abutment

P. C. C. & St. L. Ry.
C. T. Division
Ada Street to Fulton Street
Sketch Showing Method of Drainage
at Ends of Elevation Bridges
May 12, 1908
Office Eng. M. of W. - Chicago, Ill.

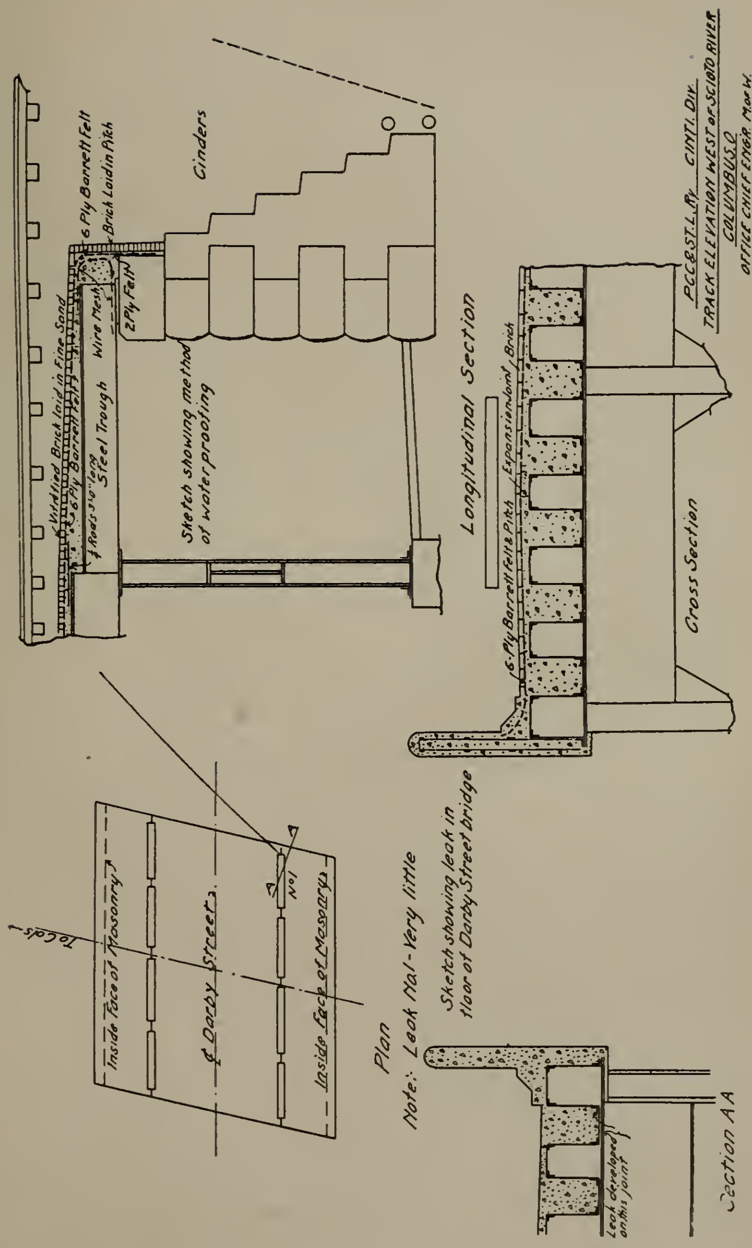


Method of Applying Edward Smith & Co's Iron Bark on elevated bridges.

P.C.C. & St. L. Ry.
CHICAGO TERMINAL DIVISION
ADA ST. TO FULTON ST.
OFFICE ENG. M. of W. CHICAGO, ILL.



Waterproofing used on Subway at Marshall Boulevard, Chicago


Vitrified Brick laid in Fine Sand
6 Ply Barrett Felt
Brick Laid in Pitch
¾ Rods 3'-0" long
Steel Trough
Wire Mesh
2 Ply Felt
Cinders
Sketch showing method of waterproofing
Longitudinal Section
6-Ply Barrett Felt & Pitch
Expansion Joint
Brick
Cross Section
P.C.C.&St.L.Ry. CIN'TI. DIV.
TRACK ELEVATION WEST of SCIOTO RIVER
COLUMBUS, O.
OFFICE CHIEF ENGR. M of W.
To Cols.
Inside Face of Masonry
℄ Darby Street
No 1
Inside Face of Masonry
Plan
Note: Leak No1-Very little
Sketch showing leak in floor of Darby Street bridge
Leak developed on this joint
Section AA

Englewood. These subways were made of through bridges with shallow I-beam floors with a one-half-inch plate covering the top of I-beams. The rail rested directly on the one-half-inch floor plate and was fastened to it by means of rail clips and bolts, and the entire top surface was waterproofed with a coal-tar preparation. This floor has always leaked through the bolt holes which fasten down the rail, and at some other places in the plate floor. The waterproofing was not carried over the back wall properly and the water would run down on the face of the abutment. We have taken care of this leakage now by placing troughs underneath the track and under the rail to carry the water to the curb line.

In the train shed at Chicago, which covers eleven tracks and is 600 ft. long, the platforms are built of an asphalt mastic placed on concrete, which has remained tight since the platform was put in, except over the supports, where the material has cracked and allowed some water to pass through, but not to any great extent. The trough in which the track is placed is filled with concrete and originally it was filled with a ballast above the concrete. This trough has leaked very badly ever since it was put in, and we have had to remove the gravel so that we could concentrate the leaks to certain places. We are experimenting now with one track to see if we can make it watertight, but, as the work was done this summer, we are unable to say what the results will be.

(29) ILLINOIS CENTRAL RAILROAD.

We furnished a statement last year similar to this, showing a subway which we have had waterproofed at Champaign. This structure is still in good condition.

About two years ago we waterproofed a steel viaduct on our lines in the city limits of Chicago and the work was done as follows:

1. The structure waterproofed was first covered with concrete, the deck portion being covered with a concrete slab and in the through girders the I-beams were covered with concrete.

2. The reason the structure was waterproofed was on account of keeping the moisture away from the reinforcing steel and from the structure itself.

3. The material used was felt and burlap.

6. This waterproofing has been on 18 months now and does not show any sign of leaking.

7. This waterproofing consisted of five layers of felt and one layer of burlap, all thoroughly saturated with pitch.

(30) BALTIMORE & OHIO RAILROAD.

For a time only a portion of our structures were waterproofed, but now all solid-floor bridges, arches and such retaining walls as are located in cities are treated by some method to prevent seepage of water as far as possible.

The reports on the result have not been full or complete, therefore the questions in the circular are answered as well as the information at hand will permit. There has been no marked success or failure in any of the methods adopted, as the conditions vary, and the details in the method of applying are not always uniform.

1. Solid-floor bridges, arches and retaining walls.

2. Thus far we have had no occasion to provide against head of water.

3. (a) Barrett's Felt has been used in a few instances, and given good results. (b) Sarco Waterproofing Compound. First coat, Sarco Primer, applied cold. Second coat, Sarco Compound No. 6, with burlap while hot, and laid parallel to tracks, with lap of one foot. Three heavy swabbing coats, three feet in width, at a time, on which were placed one-half inch of sand. Upon the sand was applied a layer of concrete 2 in. thick. (c) Bermuda Asphalt has been used. (d) Young's Patent Mixture has been used on outside of subway walls with some success.

We have no particular report on bridges referred to in this circular, other than to say that none were waterproofed prior to 1908, and some on which Sarco Waterproofing was used were built during the past and present year.

(31) MICHIGAN CENTRAL RAILROAD.

1. Floor slabs and backs of all retaining walls were waterproofed. 2. See above (does not depend on character of soil or location of water). 3. On floor slabs the following proofing is used: One coat of Sarco primer on the concrete, then 3-ply burlap dipped in Sarco No. 1, then one-and-one-half-inch Sarco Mastic mixed with torpedo gravel. On the backs of walls the following is used: One coat of Sarco primer and one coat of Sarco No. 1 (mopped on). We have also used about 10 per cent. of ground clay incorporated in concrete mixture, but have not had time as yet to judge its efficiency.

8. We have been using tar felt several years, but have had no data as to its lasting qualities.

(32, 33) GRAND TRUNK RAILWAY.

Our work of this nature has been almost entirely of an experimental character and most of it of recent date. Generally we have not met with much success, owing to contraction and expansion of the waterproof covering. We have tried asphalt, iron bark, hydrex compound with 3-ply felt, coal-tar pitch and 3-ply felt paper, coal-tar pitch without paper; some have failed and others are not yet determined, but all are more or less unsatisfactory. One of the earliest experiments with cement mortar over concrete and swabbed over when quite dry with hot coal-tar pitch has so far shown no case of failure.

1. Plate girders, ballast floor, both deck and through.

2. Both gravel and rock ballast. Head of water not to exceed 12 in.

3. Concrete, coal-tar pitch and roofing felt.

6. Design "A" in use three years; occasional small leak has developed, due to section men puncturing felt with lining bars.

Design "A"—First construction, summer 1908; number of spans constructed, 2.

Design "B"—First construction, summer of 1908; last construction, fall 1910; number spans constructed, 19.

Design "C"—First construction, summer of 1908; last construction, fall 1910; number of spans constructed, 11.

(34) NASHVILLE, CHATTANOOGA & ST. LOUIS RAILWAY.

1. Concrete block and hollow tile walls of pent houses over elevator shafts. 2. Blowing rains penetrating the walls. 3. First applied Elaterite, which failed by curling up and cracking; next applied Bay State Cement coating, which failed by wearing off. 6. Have lately applied "Annapolis mixture," composed of coal tar, Portland cement and kerosene, i. e., coal tar 16 parts, Portland cement 4 parts, kerosene 1 part. (a) Elaterite 1909, Bay State 1910, Annapolis mixture 1910.

(36) CHICAGO & NORTHWESTERN RAILWAY.

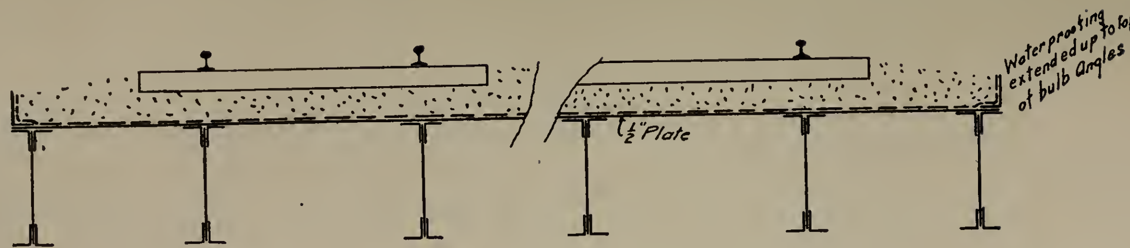
1. Stone masonry arch. 2. Water was leaking through barrel of arch and destroying limestone of which arch was built. 3. Asphalt. 6. Results obtained were satisfactory. (a) Arches built in 1864, limestone masonry. Asphalt waterproofing was applied in 1897. Examined in 1907, just before being torn down to make way for double track improvement. 7. We consider the waterproofing of these arches prolonged their life until it was necessary to take them down to make room for double-track improvement. 8. Have not used felt for waterproofing purposes long enough to determine the lasting qualities.

(37) NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

1. Subway at Exchange Street Station, Buffalo, 20 ft. clear span, 230 ft. long, under Passenger Station and twelve tracks.

2. Conditions were very unfavorable on account of so many surface sewers which could not be drained until main sewers in the subway were completed. Also the 36-in. sewer carrying off all the water from the station is two feet higher than the bottom of the subway, making it necessary to keep pumps going day and night to keep the water out. Also the continuous dripping from coaches and engines made the job a wet one and difficult to handle.

The waterproofing on the bottom and the sidewalls is satisfactory, and find very little, if any, leakage, but the roof of the subway is a failure, due to the limited time in which the work had to be done under traffic which was so limited that only one track could be taken out of service at one time, while the concrete, as well as the waterproofing, was put in place. In fact, the concrete had to be put in under one track in one day and the track closed up again at night for traffic, so that the concrete did not have any chance to set properly, and the continuous jar of trains and engines going over it cracked it more or less. The same conditions had to be



Cross Section

Water-proofing

$\frac{1}{2}$" Steel plate riveted to top flange of girders shop painted with one coat of red lead mixed with pure linseed oil.

Upon steel plate one coat of hot coal tar pitch well swabbed on.

$\frac{3}{4}$" of sand saturated with hot coal tar pitch rolled down to hard surface with hand roller to cover rivet heads.

Three layers of 10 oz tarred roofing felt cemented together. with hot coal tar pitch top surface finished with same material and sprinkled with sand before cooling

4" Sand

10" of Gravel

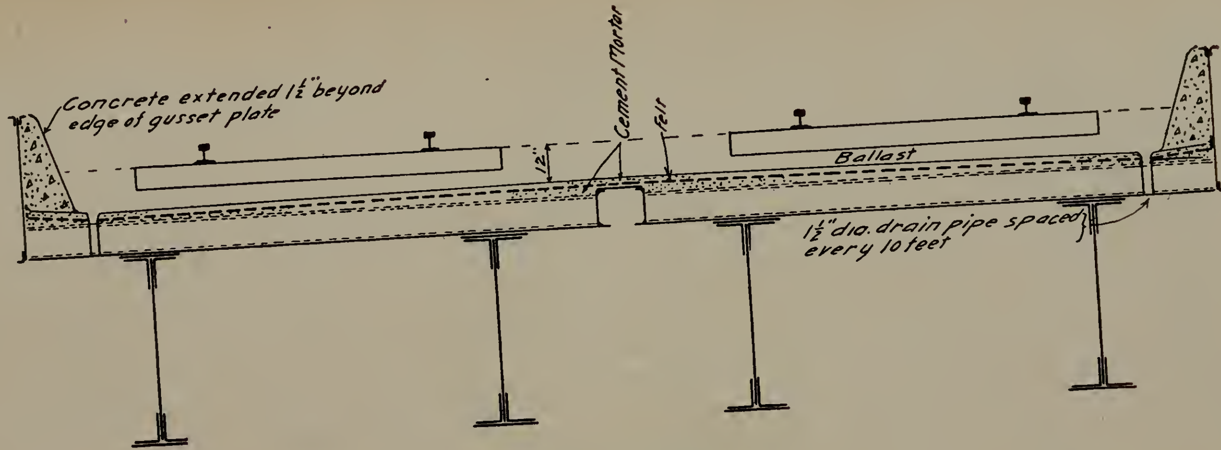
A

Grand Trunk Ry.

Bridge No 154 - Mile 275.64

2nd District-Eastern Div.

Beloeil Public Road.



Cross-Section

"B"

Grand Trunk Ry.

Bridge No. 35 Mile 209 53

18th District Southern Div.

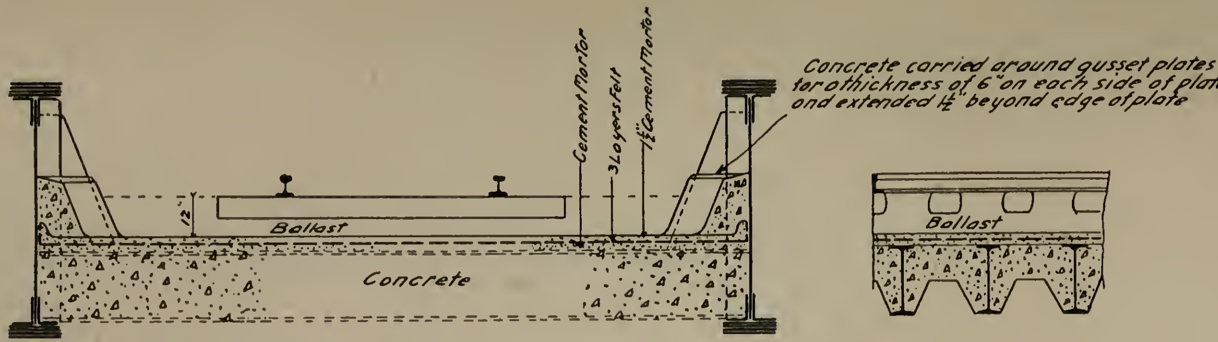
Belle River Bridge

Water-proofing

9" I Beams spaced 15" Ctrs filled to full depth with concrete. Upon top of beams a coat of cement mortar graded to drain holes and finished with a smooth surface.

Upon this three layers of 10 oz roofing felt laid length wise with a lap ⅔ the width of the roll and carried 6" up the sides of the girders and gusset plates. Each layer cemented together with hot coal tar pitch, the top surface finished with hot coal tar pitch and sprinkled with sand before cooling.

Upon the top of waterproofing a "protective coating" of cement mortar 1½" thick and graded to drain holes.



Cross-Section

Waterproofing

20" I Beams spaced 2'0" ctr's filled with concrete as shown.
Upon top of beams a coat of cement mortar graded from center to back of ballast walls and finished with a smooth surface.
Upon this three layers of 10 oz roofing felt, laid lengthwise with a lap ⅔ the width of the roll and carried 6" up the sides of the girders and gusset plates. Each layer cemented together with hot coal tar pitch, the top surface finished with hot coal tar pitch and sprinkled with sand before cooling.
Upon the top of waterproofing a "protective coating" of cement mortar 1½" thick and graded to back of ballast walls.

"C"

Grand Trunk Ry.

Bridge No 51 Mile 125 64

20th District-Middle Div.

Wherle Creek Bridge

met in placing waterproofing. As the sides, as well as the top, were surrounded by water, an excellent job would have been necessary to be absolutely tight.

A short time ago we put in sewers to drain the water away from the roof, which has greatly improved the condition.

3. Asphalt felt, burlap, Sarco Waterproofing Compound No. 6, brick encasing over top and sidewalls.

6. Sidewalls and bottom all O. K. Roof leaks a little. (a) Applied May, June and July, 1908. Examined June, 1910. (b) Sidewalls and bottom all O. K., one leak to 100 ft. square. Roof leaks very little.

7. Since subway has been completed a coating of waterproofing has been put on inside of subway by the Hydrolithic Waterproofing Company of New York, but the roof still leaks some.

8. At last inspection it was all O. K., but was not in use long enough to give it a fair trial.

(38) LONG ISLAND RAILROAD.

1. Cellar. 2. Head of water, 7 ft. 3. Barrett 5-ply. 6. First class. (a) Applied in spring of 1909 and examined in spring of 1910. (b) Good; no leaks.

It might be added that we have waterproofing that is in for five years, under good, heavy water pressure, which has withstood the test in every way, and consider, with 5-ply of felt properly applied with a proper amount of pitch between the layers, that waterproofing is almost indestructible as far as decay is concerned.

(39) PHILADELPHIA & READING RAILROAD.

We would refer you to our letter of November 1, 1909, on the same subject, and advise further in reference thereto. Since that time a number of bridges have been erected of through plate girder type with solid steel trough floors filled with concrete and waterproofed with natural rock asphalt mastic without further protection. These structures have just been completed and the treatment has been exactly the same as that described on November 1 last, except that bent flashing angles have in addition been riveted to the webs just above the waterproofing.

As to the structures referred to last year, in answer to your letter—

6. Oldest application, fall of 1908; examined August, 1910. None of the structures, steel-floor bridges or arches which were treated with felt show any leaks—they are practically watertight. Out of seven steel bridges with asphalt mastic and no protection, three show a few leaks along the main girders, but the leaks are not serious. These bridges had drainage down the trough floors to a hole in the center, with nipple discharging into a metal gutter beneath. Leaks occur around these nipples and the detail is not a satisfactory one. It is corrected in the bridges now being erected by filling the troughs with concrete and making the waterproofing in a plane on top of same, the drainage being to either or both ends of the span.

8. The oldest felt under observation is but two years old, and therefore have no data to present.

(40) NEW ORLEANS & NORTHEASTERN RAILROAD.

In this climate there is little need for waterproof masonry, on account of frost effects.

To prevent moisture arising, the practice is to use pitch or felt, and some use a slate course; as to which is best, we have not had sufficient experience.

(41) CHICAGO & NORTHWESTERN RAILWAY.

Our experience covers two kinds of waterproofing:

1. Asphalt on concrete thoroughly dried. Have used priming coat of asphalt dissolved in naphtha and on this laid one-half inch of asphalt and sand under a head of sixty feet of water, with good results.

2. Have also on concrete roofs used the Sylvester Solution, which consists of a wash of Castile soap followed by a second wash of alum. The method is described in "Baker's Masonry Construction" on page 179. We find that this gives excellent results.

(42) CENTRAL RAILROAD OF NEW JERSEY.

The only thing that occurs to me as desirable to mention to supplement our letter of November 16, 1909, is that our experience with our plan No. 6009-D-3 indicates that the waterproofing should be carried somewhat higher on the girder in order to entirely prevent the entrance of water at times when the bridge is filled with melting snow.

The plan, has, however, proved very satisfactory as a whole, and we have remedied the difficulty in later bridges.

(44) UNION PACIFIC RAILROAD.

1. North Platte, Neb. Substructure for coal conveyor at Power House, U. P. R. R. 2. First sheet or ground water is about 4 ft. below surface. 3. Platte River sand, Crushed Limestone (2-in.), Kansas Portland Cement. 6. Conveyor tunnel, crusher and hopper pits are waterproof. (a) 1907. July, 1910. (b) Perfect.

This particular case of "waterproofing concrete" is a good instance of what can be done in cases where the subsoil is coarse river sand and the water is very near the surface.

(45) MISSISSIPPI RIVER & BONNE TERRE RAILWAY.

About four months ago we covered the concrete floor of a ballast floor through plate girder with the "Barrett Specification" for roofs. It is holding perfectly, but of course is much too soon to express an opinion.

(46) UNION STOCK YARDS & RAILROAD CO.

1. Reinforced concrete reservoir, 58x200x20. 2. 20 ft. 3. Concrete coated with Medusa Compound. 6. Fair. (a) August, 1909. September, 1909. (b) Good.

7. Were no cracks. Loss of water by percolation before applied, 24 in. in 24 hours. After Medusa Compound was applied on surface, loss of water, between 3 and 4 in. in 24 hours.

(47) SANTA FE RAILWAY.

We have done comparatively little waterproofing as yet, and cannot, therefore, tell regarding the probable life of any of the work of this kind, except that which has already failed. We cannot at present give out very accurate record as to the cost per sq. ft. of surface waterproofed, since this kind of construction is still in course of development, and I expect within the next year or two its cost will be very much reduced.

Our first attempts in the way of building waterproof floors were on the joint track elevation bridge floors, Chicago. On this work we used two-inch creosoted flooring, this flooring being tongued and grooved. After laying very carefully, the seams were caulked with oakum and filled with caulker's pitch. After this the floor was mopped completely over with a good application of refined coal-tar pitch.

For several years this waterproofing proved to be effective, but after, say, five years, it commenced to leak, and with each succeeding year it leaked worse. Last season we took out the ballast, cleaned off the floor and rewaterproofed all of them, using what is known as the Sarco process

When we built the first section of the Joliet track elevation bridges, some four years ago, we used creosoted planking for covering the floor I's. This planking was surfaced four sides and dressed to exact thickness. The floor was waterproofed by being covered with four layers of burlap, which were thoroughly mopped in with hot Elaterite gum. On top of the final layer of burlap was placed a mopping of Elaterite, perhaps ⅛ in. or ¼ in. thick. This waterproofing was covered with a layer of 1¼-in. creosoted planking, which had been surfaced four sides.

We have four bridges in the Joliet track elevation work which were waterproofed in the above manner. The first winter it worked beautifully. At the time the waterproofing was put in on one of the bridges we wanted to determine whether our work was well done, so we dammed up the ends of the bridge with clay and then filled the bridge with water, this water standing about ten inches in depth over the floor. It stood in this condition for forty-eight hours without showing a leak. The second winter after this floor was put in proved disastrous, the sudden drop in the thermometer from a high fall heat down to ten or twelve degrees below zero proved too much for the Elaterite gum. Early in the spring the floors commenced to leak very badly and the gum dripped. They have not yet been repaired, and on two of the bridges the floor from the street below looks like the roof of a cave having a lot of stalactites hanging down from same.

The cost of this latter creosoted floor and waterproofing was about sixty cents per sq. ft. The waterproofing which we will shortly put on to the remainder of the Joliet track elevation bridges, which is the Sarco process, I expect will cost us about sixteen cents per sq. ft. This latter waterproofing is put on to reinforced concrete floors. We cannot tell anything as to the probable life of the Sarco waterproofing from actual experience.

(48) PITTSBURG & LAKE ERIE RAILROAD.

1. Fifty-foot, four-track, half-deck and through-girder bridge. Floor stringers of 15-in. I-beams, spaced 15 in. c. to c. Space between floor stringers filled with concrete. A ballast bridge.

2. Waterproofing was required to protect the stringers and prevent drip on people and vehicles using the undergrade crossing.

3. Sarco No. 6 waterproofing with 8 oz. open-mesh burlap, 1¾ in. of cement mortar on top of the waterproofing.

6. (a) Work done September, 1909. Work examined November, 1910. (b) Present condition good. Number of leaks, none.

7. The above is typical of five similar bridges built and waterproofed, with the exception of one, which was concreted and waterproofed in weather conditions which were unfavorable to good results.

The weather was very cold when the concrete was placed in the floor, and there is evidence that it was slightly frozen, and the waterproofing was applied when it was necessary to artificially dry the concrete to obtain anything like favorable results from the waterproofing. After heavy rains we have observed several leaks, but these have become less frequent and it may be that in time they will be stopped.

8. We have no experience with felt in connection with Sarco. The waterproofing on one undercrossing, which was covered with pitch and felt, has not proved entirely satisfactory, especially on the inclined surfaces, because of the loosening of the felt from the concrete, thus allowing water to get in behind the waterproofing. This failure is probably due largely to the pitch and not chargeable to the felt.

(49) EL PASO SOUTHWESTERN SYSTEM.

Replying to attached letter and circular about waterproofing masonry, we have recently waterproofed four reservoirs lined with four to six inches of concrete, and carrying a depth of 12 ft. of water. We used soap and alum first, and finished the work by applying a coat of hot asphalt or cold Elaterite waterproofing paint. The latter is an asphalt preparation. Two coats of soap solution and two coats of alum solution were applied alternately, beginning with the soap. These materials were selected as the result of office tests, in comparison with various waterproofing compounds incorporated with the cement mortar. The test showed that careful application of strong soap and alum solutions would make the concrete actually watertight. Similar results were shown by the asphalt and Elaterite. These applications have actually made the reservoirs watertight. We have found, however, that it is exceedingly difficult to make the asphalt adhere permanently to the concrete. This trouble, in our case, is doubtless accentuated by the prior application of the soap and alum, which renders the surface slick and glassy, on which water will roll as though it were on plate glass. Indeed, I think the subsequent application of the asphalt and the Elaterite paint probably unnecessary. Nevertheless, the Elaterite paint is adhering perfectly, and, in itself, proving to be a very efficient waterproofing for the period of 12 months since it has been applied.

In our tests we have found that the primary requisite for watertightness is a dense concrete mixture, rich in cement. We have also made portions of this concrete work entirely watertight by a rich cement plaster on the surface.

DEFINE MONOLITHIC CONSTRUCTION. REVISE REPORT ON DURABILITY OF ALL MONOLITHIC CONSTRUCTION IN ARCHES OR LARGE ABUTMENTS WITH WING WALLS.

Your Committee was instructed to define monolithic construction, and respectfully submits the following definitions for approval:

Monolith of Concrete.—A single mass of concrete made without joints by a continuous operation of construction.

Monolithic Concrete Construction.—Monolithic concrete construction is the building of a single mass of concrete without joints by a continuous operation.

In order to judge of the merits of monolithic construction we should examine the various causes which bring about the failure of masonry construction to ascertain whether or not monolithic construction will either prevent or delay failure when masonry is subjected to conditions that are likely to occur during their lifetime.

Below are given causes for various masonry failures as taken from reports of various railroads, and a report by Prof. Swain, which was gathered from various periodicals for the use of the Committee:

(1) Faulty Design.

- (a) Where masonry is placed on grillage above the water line, the grillage rotting and allowing masonry to settle.
- (b) Where grillage rests on piling and where the designer used too high a unit stress for timbers in compression.
- (c) Where U-abutments have their wings built too light.
- (d) Where the designer has allowed too high a unit pressure on the earth in front of the abutment or on piling upon which it may rest.
- (e) Settlement which frequently causes a crack to appear where the wing leaves the main portion of the abutment.
- (f) In case of arches, the wings sometimes separate from the body of the arch or the arch will frequently crack from

10 to 20 ft. on each side of the center line of the track, depending upon the height of the fill.

(g) Lack of proper drainage.

(2) Poor Material or Poor Workmanship.

(3) Temperature Cracks.

(4) Disintegration of the Masonry.

(a) On account of the freezing and thawing of exposed surfaces of masonry, particularly where water drips through an arch ring or where the masonry near the ground is exposed to alternate freezing and thawing.

(b) On account of masonry being exposed to salt water, alkalies, acids or heat.

(5) Improper Filling.

(6) Scouring Away of the Material Underneath the Masonry.

(a) On account of unusual freshets.

(b) On account of driftwood, wagon bridges, etc., lodging against the masonry.

(c) Account of ice gorges.

(d) Account of the size of the opening being too small, which causes the water to rise during a freshet and which increases the velocity of the stream sufficient to scour away the material underneath the masonry.

(7) Material Sliding and Carrying the Masonry With It.

Cause 1.—If the settlement in cases (a), (b), and (d) was not uniform in a large monolithic structure they would probably crack unless they were reinforced so as to prevent settlement cracks. If the structure was an ordinary single-track abutment up to about 20 or 25 ft. in height it would probably settle without cracking. If the abutments were built in sections the different sections would be divided in a vertical plane and prevent unsightly cracks.

In the case of arches under high fills and on ordinary soils it is difficult to prevent cracking of the arch abutment and ring unless reinforcement is used, on account of the pressure on the foundation in the center of the arch being very great when compared with the pressure at the end of the wing walls. The monolithic character of the arch abutment and the arch ring are not strong enough to distribute the load uniformly over the foundation, and when a slight settlement occurs in the center it causes cracks that are unsightly but seldom dangerous.

Cause 3.—Several railroads reported temperature cracks in their abutments, while other roads reported abutments built of plain concrete in lengths of from 60 to 100 ft. without cracking, and when the abutment was reinforced in lengths of 150 ft. without cracking. There is evidently a wide difference of opinion as to the effect of changes of temperature on large monolithic structures. The front of the abutment has no forces to prevent its free contraction and expansion on the back, side and bottom of the abutment; however, the concrete contracts and expands more than the material adjoining it and hence when the movement occurs the structure must be strong enough to overcome the friction between it and the adjoining material, or crack.

Causes 5 and 7.—A monolithic structure well designed will resist failure from both of the causes better than an abutment built in sections.

Cause 6.—In designing waterway openings the size of the opening is selected to take care of the maximum amount of water that is likely to come to the opening. It frequently happens that the amount of water has been underestimated or that the opening has been blocked by driftwood, ice gorges or other material which has induced scour in the bed of the stream or raised the high-water mark, or both. When the scour line is below the foundations of the abutments they are apt to move and tip forward or settle bodily downward. When this happens a monolithic abutment will resist the pressure back of it better than one built in sections, because when one portion of the abutment is undermined the balance of the abutment will assist in preventing failure, and, even if the abutment does tip forward, the movement at times is slow, and failure can be prevented by relieving the pressure at the back or putting in props across the bridge opening.

In building abutments for subways it is frequently impracticable to build them as a single monolith, and, even if it were practicable, the abutment when underneath a number of tracks would be long, not very high and any slight settlement would cause an unsightly crack. The abutment would be in a prominent place, where any crack would be observed by the general public and create unfavorable comment.

Again, when abutments are built in horizontal layers and the work is not done continuously, wherever the work has been stopped long enough to allow the lower portion to set before placing the upper portion a seam has been found in the concrete, and when the back filling has been made and become saturated with water the water will pass through the concrete through this seam. In city work this seepage is unsightly, it will form ice on the sidewalks in the wintertime and the action of the frost will distintegrate the concrete. For these reasons it is desirable that when abutments are built in sections they be built of such length that each section can be built continuously.

CONCLUSIONS.

These conclusions are based upon the supposition that the structure is well designed and that the foundation is good:

(1) That monolithic concrete construction may be used without danger of cracking for abutments of any length that the working conditions will permit, provided the length does not exceed about three times the height.

(2) That where abutments with wing walls are not of monolithic construction, joints should be provided at the intersections of the wing walls and the body of the abutments.

(3) The reinforced concrete abutments may be built in units of any length that economic conditions will permit.

(4) That monolithic concrete construction may be used for arches where the conditions will permit, otherwise the arch ring should be constructed with radial joints.

PRESENT TYPICAL PLANS OF RETAINING WALLS AND ABUTMENTS, PLAIN AND REINFORCED, WITH COMPARISON AND RECOMMENDED PRACTICE.

Your Committee reports progress on subject of Retaining Walls and Abutments, Plain and Reinforced, and suggests that the work be reassigned for the coming year.

INVESTIGATE AND REPORT ON THE USE OF REINFORCED CONCRETE TRESTLES, TYPICAL DESIGNS AND COST.

The report of the Committee on Masonry, made at the 1909 convention of the Association, gave the names of three railroads which were using reinforced concrete trestles, together with some information as to the type of trestles and their cost. These roads were the Wabash Railroad, the Chicago, Burlington & Quincy Railroad and the Cleveland, Cincinnati, Chicago & St. Louis Railway. These railroads commended this type of construction and reported that the structures had given good satisfaction.

Through E. H. Fritch, Secretary, a circular letter was sent out on October 26 to a large number of railroads, asking for the extent of the use of reinforced concrete trestles, the length of time they had been in service, their present condition and apparent durability and the approximate cost for ordinary conditions. Forty-six replies to this letter have been received. The Chicago, Milwaukee & St. Paul Railway Company report that they have constructed 83 reinforced concrete trestles of the thin-pier and solid-deck type, aggregating 8,359 lin. ft. of single track. These structures replace timber trestles. The slabs were generally built at a convenient point and finally placed by means of a locomotive derrick. Some of the reinforced concrete trestles have been in use two years and their condition is very satisfactory. The length named above does not include subways such as are used on the Evanston track elevation, girder bridges which have been replaced with deck slabs, or highway openings with single slabs, of which there are about 2.8 miles on the Chicago, Milwaukee & St. Paul Railway. During the past two seasons many of the smaller pile and timber trestles of the Northern Pacific Lines in Montana have been replaced with reinforced concrete structures consisting of slabs supported on thin piers resting on concrete piles. The slabs and piles are cast at a central plant. The Chicago, Rock Island & Pacific Railroad is building a reinforced concrete trestle of the thin-pier type 291 ft. in length. The Great Northern Railroad and the Chicago Great Western Railroad have made and adopted standard plans, and expect to build such structures, and the Delaware, Lackawanna & Western Railroad has used reinforced concrete for coal trestles. The other replies state that the roads have not used this type of construction to replace timber trestles, though a number of them use decks of reinforced concrete and structures built in place. The companies named in the 1909 list report that the reinforced concrete trestles continue to be satisfactory. The Chicago, Burlington & Quincy Railroad has now built approximately 20,000 ft. of their standard reinforced concrete trestle.

In view of the limited time this form of structure has been in use, it does not seem best to present typical plans for reinforced concrete trestles at this time. However, as there is much interest in this construction, there are appended to this report the plans of trestles used by two railroads as illustrations of two forms of construction, the pile-bent form and the thin-pier form. Figs. 1 and 2 give one of the forms used by the Chicago, Burlington & Quincy Railroad, the pile-bent form. The thin-pier plan given in Figs. 3, 4 and 5 is that used by the Chicago, Milwaukee & St. Paul Railway. There is also given in Fig. 7 plan of the end bent used by the Northern Pacific Railway. Here five piles are used, both in the end bents and in the intermediate bents. Figs. 8, 9 and 10 give views of completed structures. Attention is also called to an excellent article by Mr. C. H. Cartlidge, Bridge Engineer of the Chicago, Burlington & Quincy Railroad, which has been published in the Journal of the Western Society of Engineers for October, 1910, and reprinted in engineering and railroad journals.

Respectfully submitted,

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L. N. Edwards, Assistant Engineer, Grand Trunk Railway, Montreal, Canada.

A. H. Griffith, Assistant Engineer, Baltimore & Ohio Railroad, Cumberland, Md.

Richard L. Humphrey, Consulting Engineer, Philadelphia, Pa.

Howard G. Kelley (*Past-President*), Chief Engineer, Grand Trunk Railway System, Montreal, Canada.

R. T. McMaster, Inspecting Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa.

C. H. Moore, Engineer of Grade Crossings, Erie Railroad, New York, N. Y.

F. E. Schall, Bridge Engineer, Lehigh Valley Railroad, South Bethlehem, Pa.

G. H. Scribner, Jr., Contracting Engineer, Chicago, Ill.

A. N. Talbot, Professor Municipal and Sanitary Engineering, University of Illinois, Urbana, Ill.

F. L. Thompson, Engineer Bridges and Buildings, Illinois Central Railroad, Chicago, Ill.

Job Tuthill, Assistant Engineer, Cincinnati, Hamilton & Dayton Railway, Cincinnati, Ohio.

Committee.

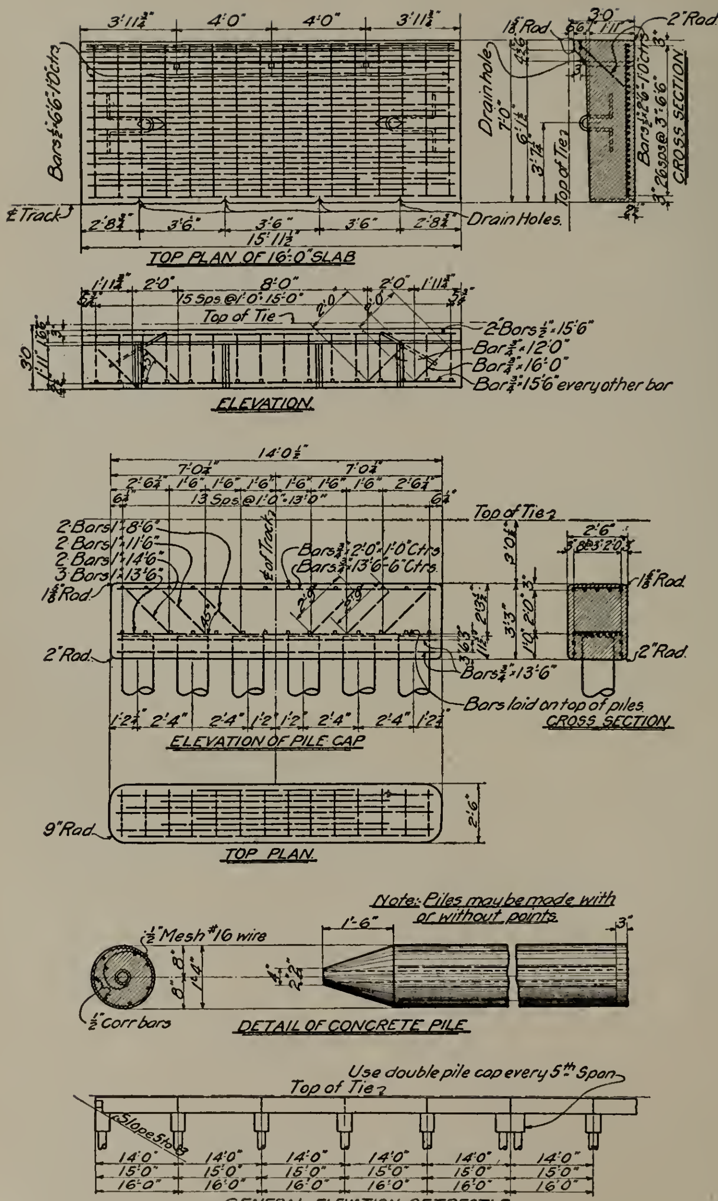


FIG. 1. STANDARD CONCRETE PILE TRESTLE—CHICAGO, BURLINGTON & QUINCY RAILROAD.

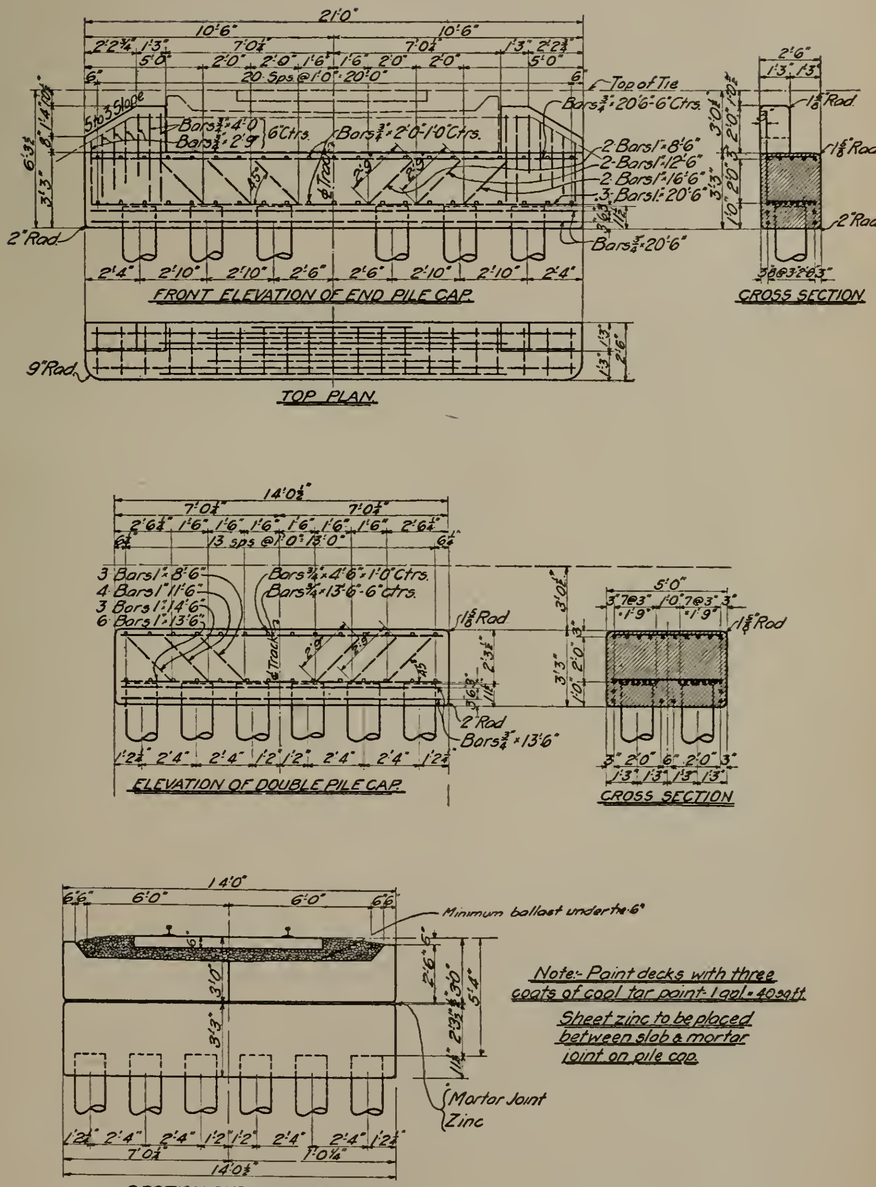


FIG. 2. STANDARD CONCRETE PILE TRESTLE—CHICAGO, BURLINGTON & QUINCY RAILROAD.

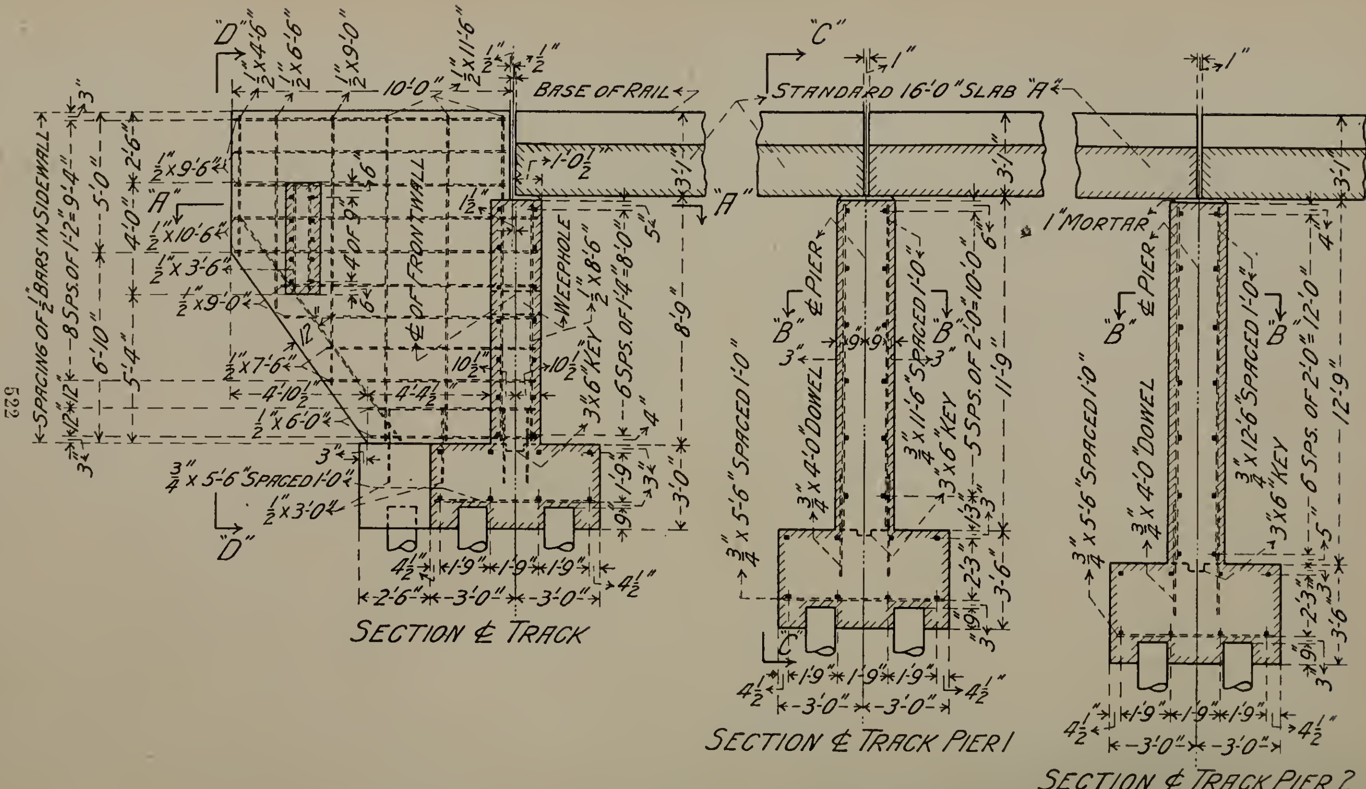


FIG. 3. STANDARD REINFORCED CONCRETE TRESTLE—CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

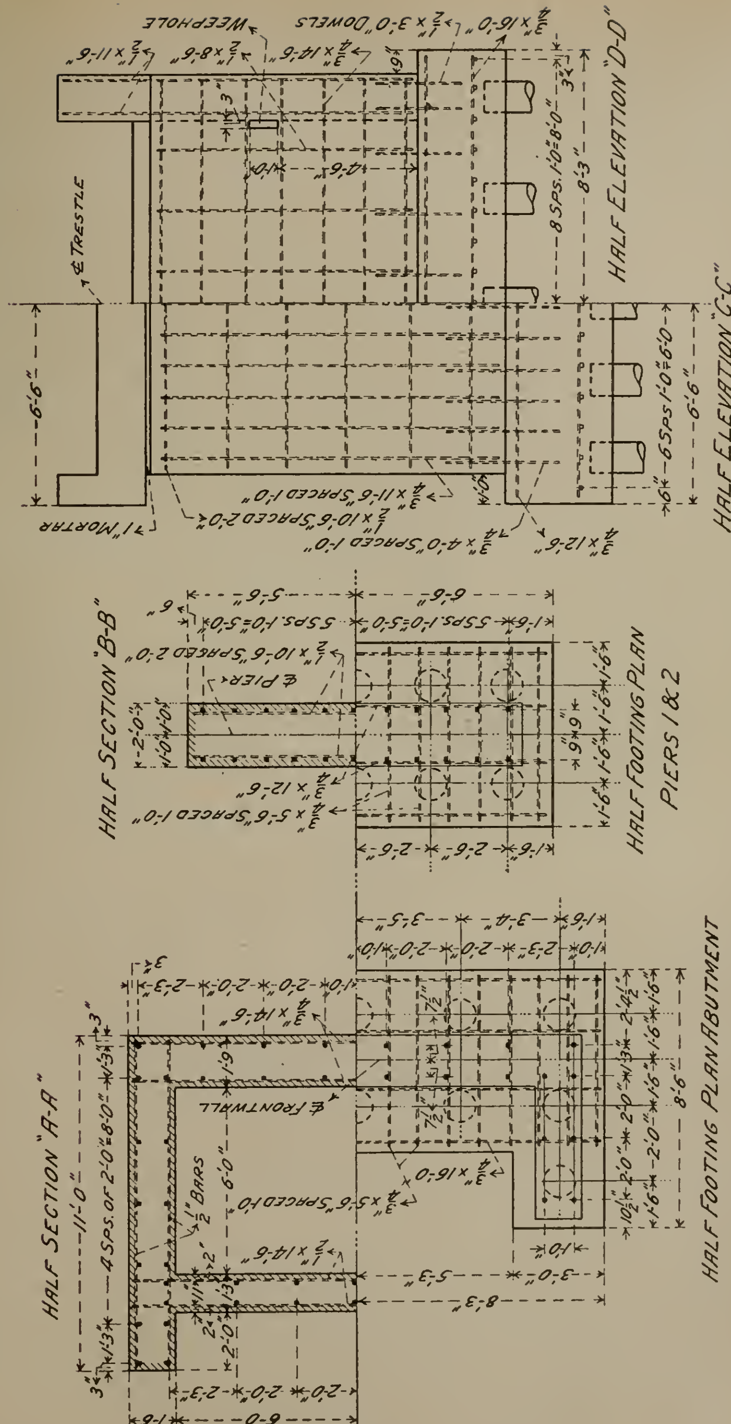
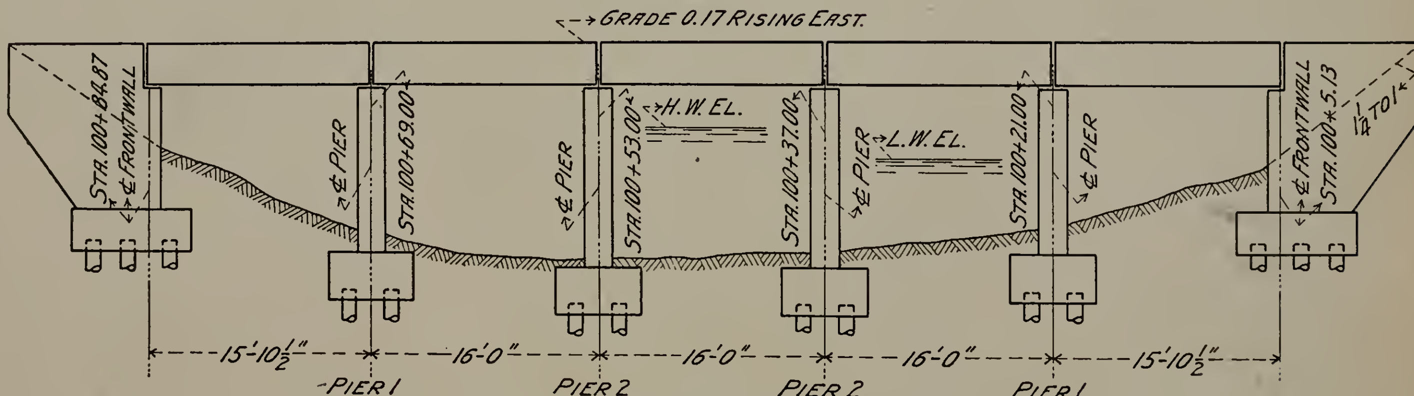


Fig. 4. Standard Reinforced Concrete Trestle—Chicago, Milwaukee & St. Paul Railway.



GENERAL ELEVATION

FIG. 5. STANDARD REINFORCED CONCRETE TRESTLE—CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

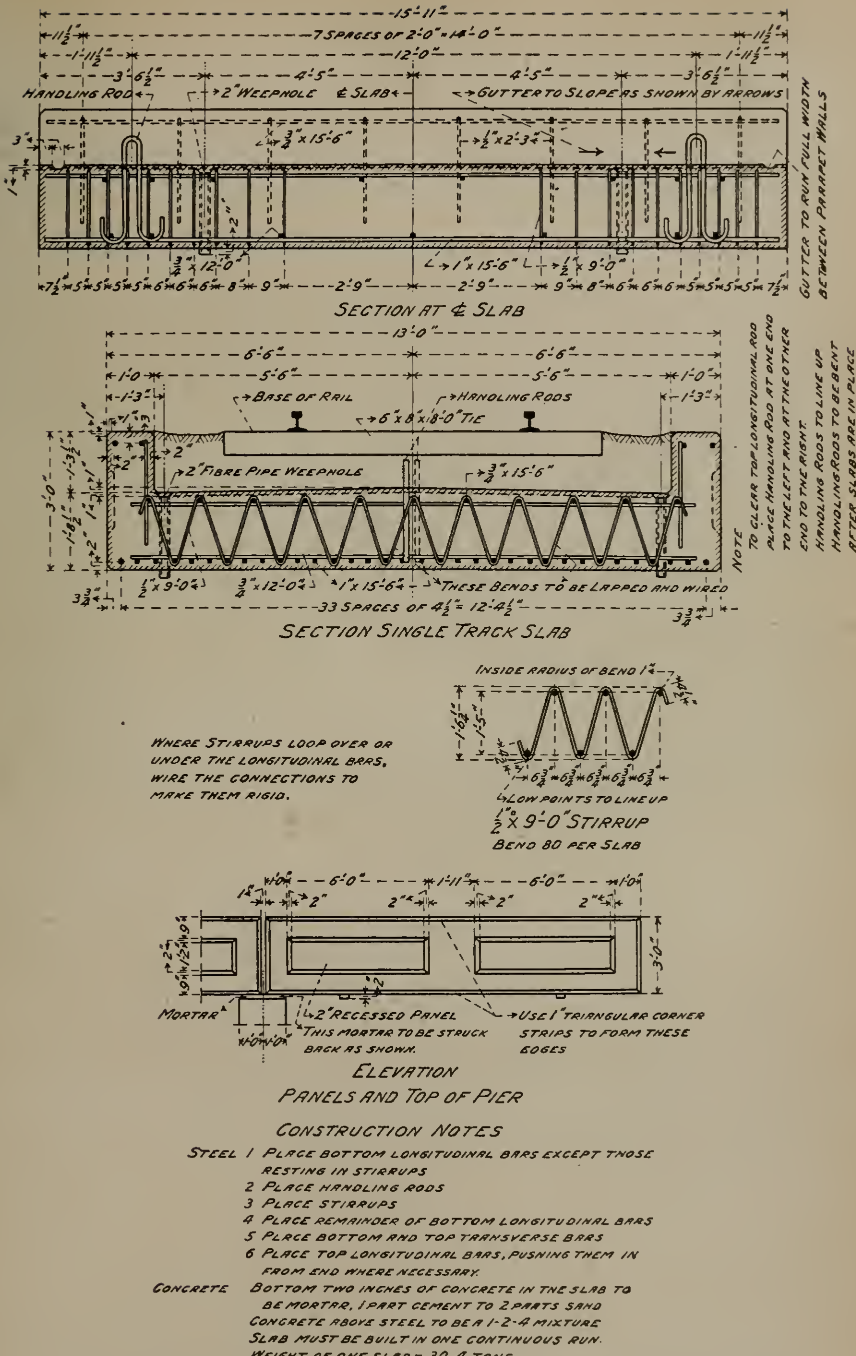


FIG. 6. STANDARD REINFORCED CONCRETE TRESTLE SLAB—CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

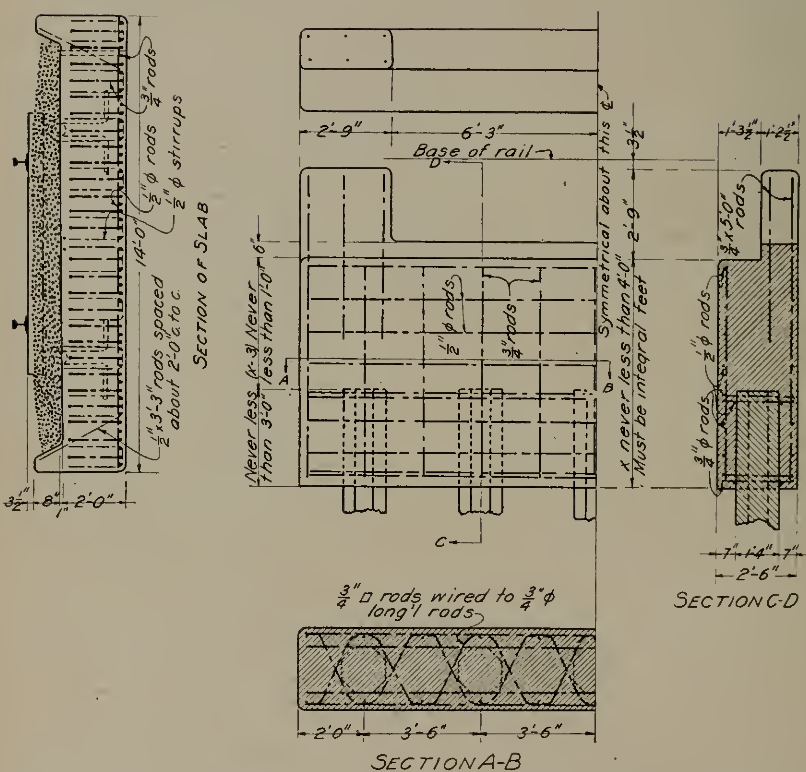


FIG. 7. END BENT, REINFORCED CONCRETE TRESTLE—NORTHERN PACIFIC RAILWAY.

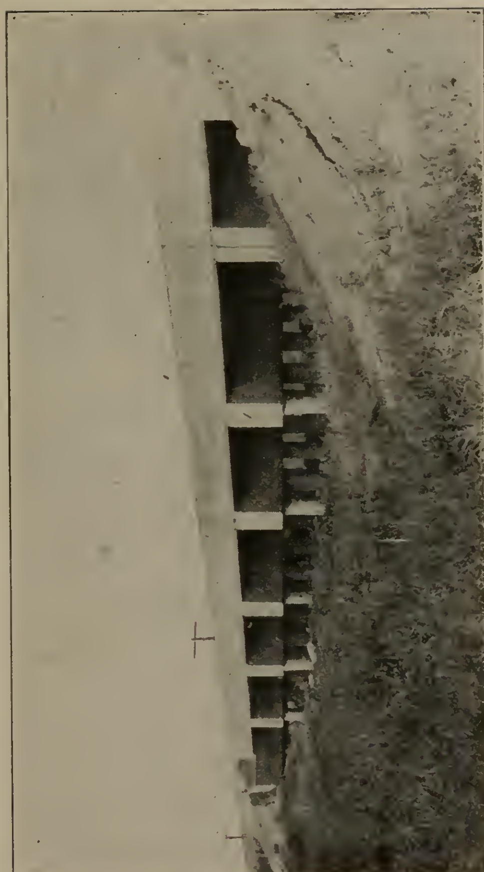


FIG. 8. REINFORCED CONCRETE TRESTLE—CHICAGO, BURLINGTON & QUINCY RAILROAD.

Fig. 9. Reinforced Concrete Trestle—Chicago, Milwaukee & St. Paul Railway.

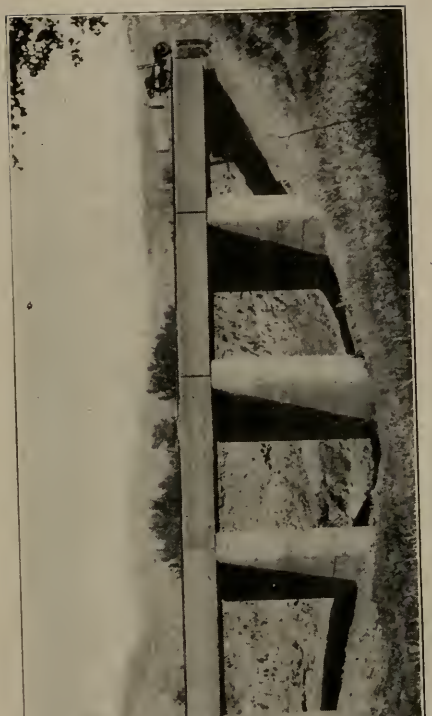


Fig. 10. Reinforced Concrete Trestle—Northern Pacific Railway.

Appendix B.

PROTECTING AND WATERPROOFING SOLID FLOOR BRIDGES.

(Bulletin 64.)

By W. C. Cushing, Chief Engineer Maintenance of Way, Pennsylvania Lines, Southwest System.

The work of separating street and railway grades in Chicago during the past 13 years has stimulated among railway engineers the study of a suitable design for a bridge floor, which will be practically water-tight, and at the same time afford reasonable protection to the metal work of the structure, because the cost of reprotecting a ballasted solid-floor bridge is very large.

In the earlier days, when the Illinois Central became the pioneer of "track elevation," preparatory to the removal of the railroad track obstruction to the Columbian Exposition, the term "solid-floor" was considered synonymous with "shallow-floor," and the bridges were constructed with such floors till it was found to be practically impossible to comply with the conditions of water-tightness, steel preservation and noiselessness. The latter condition has become a very important one, and has been a very considerable cause for the abolition of the shallow-floor, as it was necessary to put ballast between the cross-ties and the steelwork, in order to deaden the sound.

The change in style of construction has led to new problems in waterproofing and steel preservation, and it is the object of the writer to explain some of the plans used on the P., C., C. & St. L. Railway at Brighton Park and Englewood, in 1904, while at the same time as clear a comparison of results as possible will be given.

BRIGHTON PARK BRIDGES AT THIRTY-FOURTH, THIRTY-FIFTH AND THIRTY-SIXTH STREETS.

Each of these bridges has 9 tracks, as follows:

No. 1 No. 2 No. 3 No. 4	P., C., C. & St. L. Railway.
No. 5 No. 6	Chicago Terminal Transfer Railroad.
No. 7 No. 8 No. 9	Chicago Junction Railway.

In type, they are half through, single span, plate girders, 55 ft. long at Thirty-fourth Street, and 71 ft. long at the other two, with a double track between each two girders, except in the case of Track 9. (Photo, Fig. 1.)

The floor system, illustrated in Figs. 2 and 3, consists of 6 by 10 in. creosoted pine timbers laid closely together, parallel with the track, on the bottom flanges of heavy cross box-girder floor beams. The drain water is carried through these box girders in 2-in. pipes, calked in like boiler tubes, and in gutters cut in the creosoted timbers, to the low end of the bridge back of the ballast wall.

METHOD USED FOR TRACKS 1 AND 2.

A Portland cement mortar layer, 4½ in. thick at the center, and sloping to the drain pipes at the sides, where it is about 2 in. thick, was first laid on the creosoted timbers, the proportions used in the concrete being 1 cement to 5 torpedo sand, except at Thirty-fourth Street, where it is 1 cement to 6 limestone screenings. Then, on this cement layer, and on the steelwork, a layer of hot asphalt was poured and swabbed on till it became a ½-in. thick.

The work was done very early in 1904. when the temperature was below freezing every night, and frequently during the day. Owing to conditions of construction, the time could not be chosen. The bridge erectors were waiting for the next bridge. and the work, therefore, had to be hurried.

The asphalt did not adhere well to the cement, presumably on account of the moisture in the cement.

Considerable difficulty was also experienced in getting the asphalt to adhere to the steel, on account of the shop coat of oil. An attempt was made to remove this coat by burning benzine, which was lightly poured over the oil, but with poor results.

When the test was made by standing water on the bridges before use, they were all found to leak, principally around the pipes in the box girders, but were patched till entirely water-tight before being put in service under traffic.

METHOD USED FOR TRACKS 5, 6, 7, 8 AND 9.

Owing to the poor adhesion between the asphalt and the cement, it was decided for the next work to omit the cement, and substitute asphalt mastic. After considerable study, specifications for the asphalt were prepared, which, after some changes, finally took the form submitted in the Appendix. The writer is indebted to Mr. W. H. Finley, then Principal Assistant Engineer of the Chicago & Northwestern Railway, for the matter contained in them. The asphalt was purchased under the specifications from different manufacturers, and, after receipt of a shipment, samples were taken to a testing laboratory and tested.

The steelwork was first thoroughly cleaned with concentrated lye, and then painted with asphalt paint. A layer of pure asphalt gum ¼ in. thick was poured over the creosoted timbers and top of the steel box girders, and mopped on the sides of the latter till of the same thickness, after which a layer of asphalt mastic (made in the proportion of 1 asphalt to 4 of limestone screenings) was put on 4½ in. thick at the center and about 2 in. thick at the side drains. Finally, on top of all was poured a ¼-in. thick layer of pure asphalt, which, of course, had to be mopped on the sides of the girders.

All of the bridges were made water-tight under test, by patching where necessary. The work was performed in July and August.

METHOD USED FOR TRACKS 3 AND 4.

The difficulties experienced with the asphalt mastic at Englewood, which will be described later, and the good results from the protection for Tracks 1 and 2, which were apparent after an inspection September 14, succeeding a heavy rain, led to a return to the cement undercovering instead of asphalt mastic for these tracks.

A Portland cement concrete layer, 4 in. thick at the center, and about 2 in. thick at the side drains, in the proportions of 1 cement, 3 torpedo sand, and 3 crushed limestone broken to 1-in. size, except that at Thirty-fourth Street the proportions were 1 cement to 6 limestone screenings, was placed on the creosoted timber and well troweled on top, to a smooth sidewalk finish, after which it was allowed to dry thoroughly.

The steelwork was cleaned with concentrated lye and water, and the parts of steel and concrete intended to be covered with asphalt were painted with two coats of liquid asphalt, after which a ¼-in. layer of pure asphalt was poured on; then the asphalt mastic, in the proportions of 1 asphalt to 4 parts of sand and screenings, hot from the kettle, was packed and rammed, and the whole, including the box girders, covered with a finishing coat of pure gum asphalt, ¼ in. thick. The mastic was not carried over the tops of the box-girder floor beams.

Fig. 4 shows the concrete in place, and Fig. 5 a completed portion of one of the bridges. The work was done in August and September.

ENGLEWOOD BRIDGES.

These are single-track, half-through, plate-girder bridges of one span, each 72 ft. long (Fig. 6), except that the Murray Street bridge has two tracks, with three girders, while the one at Wallace Street is a steel trough floor bridge 25 ft. long, with the troughs running parallel with the track. The floor systems of the other bridges are of the same type, except that the troughs are at right angles to the track. The design is shown in Fig. 7.

On account of the intention to add a second track to these bridges in the future, it was decided to use the asphalt mastic instead of concrete for filling the troughs, the latter being completely filled so as to carry the drain water to one or both ends of the bridge.

METHOD USED AT WRIGHT, WALLACE AND LOWE STREETS.

A ¼-in. layer of pure hot asphalt was poured all over the steelwork to be covered, mopping being resorted to in the case of vertical surfaces, and the troughs were then filled with hot asphalt mastic, mixed in the kettle in the proportions of 1 asphalt to 5 parts of sand and screenings. This mastic was carried over the tops of the troughs, crowned in the center and sloped to the sides, which were built up in the form of gutters. On level track the gutters were sloped to each end of the bridge from the center. On the mastic was poured a ¼ to ⅜-in. layer of pure hot asphalt, over which, while hot, was scattered a ½-in. layer of clean gravel.

It developed during the progress of the work that the mastic, while cooling, contracted, and pulled away from the sides of the troughs, but the cracks were filled again as completely as possible with the liquid asphalt. On test, when the work was completed, the bridges were water-tight, but, in the light of subsequent effects, the cooling must have continued, resulting in very fine cracks, which caused leaks.

METHOD AT MURRAY AND UNION STREETS.

In order to avoid the contraction of the asphalt recited above, mastic blocks were molded in the proportions of 1 asphalt to 4 limestone screenings and allowed to cool. They were of such size as would just fit between the rivet heads of the troughs, and were set in place after the usual ¼-in. coat of pure asphalt had been put on the steel. The spaces were poured full of pure hot asphalt, but it was evident, during the pouring, that the cool blocks absorbed a good deal of the liquid, and it is considered possible that some voids remained near the bottom. The top was finished in the same manner as the other bridges.

Subsequent results seem to indicate that the new method did not entirely correct the old.

BRIGHTON PARK BRIDGES AT ARCHER AVENUE.

This matter deals only with the 4-track, single-span, half-through, plate-girder bridge (Figs. 8 and 9), of the P., C., C. & St. L. Railway. There is only one track between each two girders, which are 68 ft. long, and on skew.

The floor system consists of square steel troughs, illustrated in Fig. 10, and are similar to the ones used on the Englewood bridges.

Some new methods of waterproofing having been proposed, it was decided to try a different one for each track of this bridge, but in each case the shop coat was removed with concentrated lye, at a cost of about one cent per sq. ft. of surface.

METHOD FOR TRACK 1, FIGS. 11 AND 12.

The troughs were filled to the top with Portland cement concrete, mixed in the proportions of 1 cement, 3 torpedo sand, and 3 crushed stone, after which a galvanized wire netting of No. 10 wire, with 2-in. mesh, and costing 5 cents a sq. ft., was spread over the tops of the troughs, so as to rest on the rivet heads. This was then covered with cement mortar, mixed with 1 cement to 3 sand, 2 in. thick in the center, and sloping to the sides, where it is about 1¼ in. thick, thus allowing the water to drain to the sides, and thence to one end, as the bridge is on grade.

METHOD FOR TRACK 2, FIGS. 13 AND 14.

The troughs were filled with Portland cement concrete, as above, except that it was carried above the troughs, as in Fig. 13, crowned at the center and sloped to the sides. A pocket was made at the top edges, where they joined the main girders, and the surface was troweled to a sidewalk finish.

On this was placed 3 layers of Hydrex Felt, laid transversely with the track, and lapped like shingles, with 12 in. exposure, starting at the lower end of the bridge. The Hydrex is a patent saturated felt, made by Hydrex Felt & Engineering Co., in rolls 36 in. wide, and about 66 ft. long. Before placing, the concrete is swabbed with hot "Hydrex Compound," and the felt then smoothed down on it. The felt is turned into the pocket at the girders, and the cavity filled with the "Compound."

On top of the felt a ¾-in. layer of cement mortar was placed, to prevent the puncturing by ballast of the waterproof felt covering. It was laid in blocks and troweled as in sidewalk work.

METHOD FOR TRACK 3, FIG. 15.

This is the same method used for Track 2, except that the top layer of concrete has been omitted. This is to determine whether the Hydrex Felt will be punctured by the stone ballast or not.

METHOD FOR TRACK 4, FIGS. 16 AND 17.

The concrete filling was carried up to the top of the rivet heads, except that the surface was sloped from the center to the sides, and on it was placed a 1½-in. layer of asphalt. This was made by first painting the dry concrete surface with liquid asphalt, made of asphalt and benzine, after which hot asphalt was poured on to a depth of ¼ in. The liquid layer was followed by 1 in. of asphalt mastic, in the proportions of 1 asphalt to 4 limestone screenings, and this by another ¼-in. liquid layer, on top of which torpedo sand was sprinkled to harden the top.

P., F. W. & C. RAILWAY BRIDGES.

METHODS USED AT FIFTY-FIRST AND FORTY-SEVENTH STREETS.

These are steel trough floor bridges, square in section, and supported parallel with the tracks on transverse girders, standing on columns on the curb lines, and in the center of the streets, a total clear length of 68 ft., in two 11-ft. sidewalk spans, and two 23-ft. roadway spans (Figs. 18 and 19.)

For the first track, the troughs were filled with asphalt mastic without either painting the steelwork, or pouring on a coat of pure asphalt; this being done at the expressed wish of one of the asphalt manufacturers, who was given charge of this to do in the best way he could recommend. The mastic, mixed in the proportions of 1 asphalt, 3 torpedo sand, and 2 limestone screenings, was built up to 2 or 3 in. over the tops of the troughs, the center being higher, and the surface sloping to each end of the bridge. On top, a layer of pure asphalt gum ¼ to ⅜ in. thick was poured, and then sprinkled with sand to harden it. On test, immediately after its completion, the bridge was found to leak badly.

It developed during the progress of the work that the shrinkage of the asphalt when cooling was such as to leave the metal practically unprotected, and the method was abandoned.

The bridges for the remaining tracks, 10 in number, and for Forty-seventh Street, were done as follows:

(Fig. 20.) The steelwork, after being cleaned, was painted with hot asphalt and benzine, and ¼-in. layer of hot asphalt poured on and thoroughly mopped over, after which the troughs were filled to within about 3 in. of the top with cement concrete in the proportions of 1 cement to 6 limestone screenings. When this was thoroughly set and dry, the remaining depth of the troughs was filled with asphalt mastic, which was carried over their tops in a layer of 2 to 3 in. thick, somewhat thicker at the center than at the ends, and this was in turn covered with a ¼ to ⅜-in. thickness of pure gum.

There are six different bridges at Fifty-first Street. No attempt was made to remove the shop coat of oil from Nos. 1 and 2, and on No. 3 most of the experiments for removing the shop coat, which will be described later, were tried, after which it was decided to paint the steelwork of the remaining bridges with liquid asphalt, without removing the shop coat.

METHODS USED AT FORTY-SIXTH STREET.

This is a 4-track, half-through, plate-girder bridge with a steel trough floor like that at Archer Avenue.

All the troughs were filled with Portland cement concrete made in the proportion of 1 cement to 5 parts of limestone screenings.

At Track 3, the concrete was carried up over the tops of the troughs, and a finishing coat of asphalt, as in Figs. 16 and 17, for Archer Avenue, was put on.

Tracks 1 (the most easterly one) and 2 and 4 were finished in the same manner as in Figs. 11 and 12 for Archer Avenue, but the depth from bottom of tie to top of trough, about 8 in., is greater at Forty-sixth Street and permitted a greater thickness of mortar layer on top of the troughs, 3 in., with the wire netting in the center. This top layer of mortar was composed of 1 cement to 2 parts of limestone screenings.

RESULTS OF EXAMINATION MADE ABOUT JAN. 1, 1905.

BRIGHTON PARK BRIDGES.

Archer Avenue: No indications of leaks on any of the bridges. Thirty-fourth, Thirty-fifth and Thirty-sixth streets: Leaks showed plainly at every track of each bridge, but Tracks 3 and 4 showed the fewest.

The asphalt examined when the temperature was about 0° Fahr. showed it to be hard, glassy, and easily shattered by a blow.

ENGLEWOOD BRIDGES.

Every bridge, with the single exception of the one at Wallace Street, showed leaks along the girders. As the troughs are practically watertight, the only place where leaks can show is at the junction point between trough and girder, but it does not prove that the water finds its way down between the asphalt and the girder; it may occur at any other point, but the drip will always show on the girder line.

P., F. W. & C. RAILWAY BRIDGES.

All the bridges at Fifty-first and Forty-seventh streets showed leaks at the post lines, because the concrete, as well as the asphalt, cracked at those places, on account of lack of steel reinforcement. One bridge protected with asphalt was not put into service for several weeks after completion, but there was no difference in the result.

At Forty-sixth Street, up to the time of the inspection, the bridges for tracks 1 and 4 seem to be waterproof, but that at Track 2, done late in the fall, showed leaks. The top layer of the concrete, in which the wire netting was imbedded, froze during the work, which may be responsible for the trouble. At Track 3, where a concrete filling with asphalt top was used, leaks appeared along the girders, which may have been due to the asphalt pulling away from the girders.

GENERAL INFORMATION AND COMMENTS.

CLEANING THE STEEL.

Right from the start difficulty was experienced in obtaining a satisfactory adhesion of the asphalt to the steel. As soon as it became cold, it could be peeled off like paper. After a good deal of experimenting it was found that asphalt would adhere to steel in about the following order:

(1) Rusty steel; no adhesion.

(2) Shop coat of red lead or oil; slight adhesion.

(3) Shop coat covered with liquid asphalt; slightly better than 2.

(4) Shop coat burned by pouring benzine over the steel and burning it; about the same as 3.

(5) Perfectly clean bright steel; excellent adhesion.

In order to have the fifth condition, a sand blast is probably necessary, but as there was none available, other means of removing the shop coat were resorted to. The bridges had all been given a shop coat of oil, and, on some parts, red lead. The usual wire brushes and scrapers were expensive to use, and not satisfactory.

Burning benzine over the shop coat had little effect on the oil, except to soften it. It, therefore, required a number of repeated burnings to remove it entirely, which was expensive.

A paint burner, similar to the Buckeye Burner and Wells Light, was tried to a small extent, but it was slow, on account of being necessary to concentrate the flame on a small area in order to soften the oil sufficiently to be easily removed with scrapers. It was thought when this burner was made that the heat would be great enough to burn off the oil coat completely, without scraping, but it did not prove to be the case.

Cleaning with concentrated lye and lime was tried at Fifty-first Street with good results, so far as removing the shop coat was concerned, but it was found so difficult to remove entirely the lime and lye from the steel-work that the method was given up as impracticable. The lime stuck to the steel in spite of the frequent washings, and small particles would lodge in uneven surfaces around the rivet heads, where it was next to impossible to remove it.

The best results were obtained by using concentrated lye and water, in the proportions of 1 pound of lye to 1½ gallons of water. This solution was swabbed on the steel, wire brushes and scrapers were then used, and finally the steel was thoroughly washed until all the lye had disappeared. The cost was about one cent per sq. ft. of surface.

After the above methods were tried, and it was found that pretty good adhesion between the asphalt and metal was obtained by painting over the shop coat with liquid asphalt made by pouring hot asphalt into benzine, or obtaining it from the manufacturer, this plan was generally followed. When the liquid asphalt was applied, the benzine evaporated, leaving a thin layer of asphalt on the steel. A pretty thick mixture was used, and after applying two coats, the layer was about $\frac{1}{16}$ in. thick.

LABORATORY TESTS.

As it was desirable to purchase asphalt in a competitive market, the specifications in the Appendix were prepared, and the orders were based on the manufacturers' agreement to comply with them. Samples were then taken and sent to a testing laboratory for determination of qualities.

The requirements were purposely made severe, as the office the asphalt had to perform was severe.

The product of only one of three concerns fulfilled specification No. 1, the volatile test, while all stood the acid test. All but one sample did not flow at 212° Fahr., and that one did so at 196° Fahr. At 15° Fahr. below zero, about half the samples were brittle and one-half were not. This was a very severe requirement, coupled with a high temperature flow point. The requirement for supporting power, No. 7 (b), 15 lbs. per sq. in. at 130° Fahr., was made because the provision for depth of ballast between the bottom of the tie and the asphalt was small, and there would be great danger of pressing the ballast through the asphalt if too soft. All of the mastic tested stood this requirement.

EQUIPMENT AND FORCE REQUIRED.

When one track at a time was being done, the force required was about 12 men and a foreman. It took the time of 3 or 4 of them to keep up fires, cut wood, and cut asphalt, while the rest were busy heating sand

and screenings, mixing mastic, and depositing it in place, and painting, cleaning, etc. When there were several bridges to be done, 7 or 8 more men were necessary to clean and paint the next one ready for the asphalt.

The equipment for one gang was as follows:

	Each.
1 Asphalt heater, 3 bbls. capacity	$ 62.50
1 Mastic heater	105.00
2 Sand and screening heaters	20.00
Shovels, spuds for stirring mastic, brooms, wire brushes, smoothing irons.	
2 Pay-off pails	5.00
1 Dipper	2.00

The asphalt mastic mixer was 8 ft. long, and had doors for firing at one end and on both sides. Anything longer was found to be impracticable. The sand heaters were made of sheet iron. Some of this equipment shows in Fig. 5.

COST.

During the progress of the work, the cost of asphalt fell from $60 to $40 and even $35 per ton, due to the competition. This, as well as other matters, caused the unit price to vary considerably. The information is presented in Table A.

TABLE "A."

BRIGHTON PARK

	THIRTY-FOURTH STREET.				THIRTY-FIFTH STREET.				THIRTY-SIXTH STREET.			
Track No....	1 and 2	3 and 4	5 and 6	7, 8 and 9	1 and 2	3 and 4	5 and 6	7, 8 and 9	1 and 2	3 and 4	5 and 6	7, 8 and 9
Price of Asphalt, per ton...	60	40	40	40	60	40	40	35	60	40	40	†35 & 60
Area bridge, square feet....	1581	1581	1430	2145	2041	2041	1846	2769	2041	2041	1846	2769
Total cost....	$403.28	$309.11	$294.78	$356.23	$501.64	$344.05	$361.60	$610 82	$456.27	$335.46	$440.19	$665.95
Cost per square foot........	.255	.195	.206	*.167	.246	.168	.196	220	223	.164	.238	.240
Protection	Concrete bottom. Asphalt top.		All Asphalt.		Concrete bottom. Asphalt top.		All Asphalt.		Concrete bottom. Asphalt top.		All Asphalt.	

	ARCHER AVENUE				ENGLEWOOD.							
Track No....	1	2	3	4	Streets.	Wright.	Wallace.	Lowe.	Union.	Murray,	....	....
Price of Asphalt, per ton...	....	....	....	40	....	35	35	35	40	40	....	....
Area bridge, square feet....	871	871	871	871	....	936	486.5	936	936	2376	....	....
Total cost....	$326.78	$366.78	$366.78	$370.36	....	$295.34	$165.89	$305.32	$515.6	$1526.98	....	....
Cost per square foot........	.375	.420	.420	.425	....	.316	.341	.326	.550	642	....	....
Protection	Concrete Wiremsh	Hydrex. Con. top.	Hydrex on Con.	Con. bot. As. top.		All Asphalt.						

P., F. W. & C. RAILWAY

	FORTY-SIXTH STREET.				47TH STREET.	FIFTY-FIRST STREET.						
Bridge No....	1	2	3	4	....	1	2	3	4	5	6	....
Price of Asphalt, per ton...	....	....	40	....	40	35	35	....	40	40	40	....
Area bridge, square feet....	520	520	520	520	5531	3349	2292	2074	2278	2156	2521	....
Total cost....	$175.69	$144.92	$226.72	$176.50	$1976.61	$1414.45	$850.09	$754.10	$785.70	$604.76	$913 69	....
Cost per square foot........	.338	.279	.435	.439	.357	.422	.370	.360	.344	280	.362	....
Protection	Concrete and Wire mesh		Concre.e Asphalt	Concrete Wiremsh	Con. bot. As. top.	All Asphalt.	Concrete bottom, Asphalt top.					

*The cost on this bridge is low due to fact that considerable material was used which was furnished by Asphalt Company by mistake, for which no charge was made.

†6.102 tons at $35.00; 2.85 tons at $60.00.

Archer Avenue: Track No. 1, E. B. Freight. No. 2, E. B. Passenger. No. 3, W. B. Passenger. No. 4, W. B Freight.

CONCLUSIONS.

(1) Asphalt mastic is not suitable for filling the troughs of solid floor bridges, because of its shrinkage when cooling, thus defeating the objects of its use, protection of the steel, and the formation of a solid. compact mass, with such close adherence to the steel as to be water-tight.

It is felt that ample trial was made of it and that, too, with different mixtures of the best asphalt to be found. The advice of the manufacturers or dealers was freely accepted, till it was discovered that they were simply experimenting as well as ourselves.

(2) It is quite within reason to consider, in the light of the tests, that an asphalt covering next below the ballast, either over mastic or concrete, is not an efficient waterproof coating.

When the inspection was made in January only one bridge (Track 4 at Archer Avenue), prepared with this, was not leaking, but it is entirely reasonable to doubt that it is the asphalt rather than the concrete which is performing the satisfactory service.

The requirements of ductility and hardness conflict. When the asphalt is made soft enough to resist tearing apart under temperature changes, it is too soft to bear the load of traffic, a fact which has been also proved on other railroads. It is impossible to provide for a sufficient depth of ballast to overcome this objection.

(3) Ordinary concrete has not sufficient strength in itself to resist the forces tending to tear it apart at the column lines of bridges in two or more spans. Consequently leaks developed at every place of that kind.

Although it has not been proved by trial, it is quite likely that reinforced concrete will prove effective, and it will probably be tried this year.

(4) Concrete is an effective filling material for troughs, because it adheres firmly to the steel, protects it from corrosion, and can be made practically water-tight, either by the use of concrete rich in mortar, or by a solution of soft soap and alum.

Its objections are that it is:

(a) Difficult to remove in case repairs are necessary, or in view of the replacement of, or addition to, the bridge, on account of constant improvements in the property.

(b) Heavy, and adds considerable dead weight to the bridge.

(c) Costly, on account of the quantity, and the great care necessary to make a satisfactory job.

(5) Something more than filling the troughs is necessary, however. A top surface is required, graded to carry the water to the sides and to the ends of the bridge. Concrete alone is not suitable, unless in considerable thickness. To meet this condition, it must be reinforced. Nothing definite in regard to the woven wire mesh used at Archer Avenue has yet transpired, because the track, No. 1, where it was used, has not yet been put in service for traffic.

Similar construction at Forty-sixth Street on the Pittsburg, Fort Wayne & Chicago Railway was effective up to January, except in the case where the concrete was frozen.

The writer is inclined to favor the use of small rods, from ¼ to ⅝ in. thick, rather than the wire, on account of making better use of the steel, and, quite likely, greater economy.

(6) The Hydrex Felt covering, Track No. 3, at Archer Avenue, has as yet given no cause for complaint, but this is a case where time is especially needed to determine the result, because its effectiveness depends on its strength against puncture by the ballast, which is a very thin layer under the ties. It has been much used by the Chicago & Western Indiana.

(7) If, however, the Hydrex Felt should be broken up by the ballast, there is a remedy, where there is a sufficient depth of ballast, by laying a concrete sidewalk on top of it, as at Track 2, Archer Avenue, to bear the loads transmitted by the rolling stock. This concrete need not be waterproof.

(8) In the case of trough floors transverse with the tracks, there seems to be no help for it except to fill them up with a rich concrete, unless, indeed, a drain hole is cut in each, and a gutter underneath be provided, a plan which should not be resorted to except in case of necessity for a long bridge.

After this is done, one has the choice of several different ways for providing a waterproof covering.

(9) When the troughs are placed parallel with the track, a much less thickness of concrete filling can be used, if a suitable method for protecting the portions of the troughs sticking up above the concrete can be devised. It is quite certain, where columns are used, that the concrete must be reinforced at the column lines, and other expansion places.

If a plaster of cement is put over the exposed troughs, it may possibly have to be reinforced also, on account of its thinness.

The work described in the foregoing was performed under the direction of Mr. N. Neff, Engineer Maintenance of Way, and his assistant, Mr. C. L. Barnaby, Chicago Terminal Division, and they also furnished the data for the compilation of this article.

SPECIFICATIONS AND INSTRUCTIONS FOR WATERPROOFING METAL AND MASONRY STRUCTURES.

PENNSYLVANIA LINES WEST OF PITTSBURG.

SOUTHWEST SYSTEM.

I. PURE GUM ASPHALT.

olatili-ation.

1. Asphalt shall be used which is of the best grade, free from coal-tar or turpentine, and which will not volatilize more than ½ of 1 per cent. under a temperature of 450° Fahr., for 10 hours.

cid Test.

2. It must not be affected by a 20-per-cent. solution of ammonia, a 25-per-cent. solution of sulphuric acid, a 35-per-cent. solution of muriatic acid, nor by a saturated solution of sodium chloride.

xtremes f Temperature 'est.

3. (a) For metallic structures exposed to the direct rays of the sun, the asphalt should not flow under 212° Fahr., and should not become brittle at 15° Fahr. below 0° when spread in a layer of ⅛ in. thick on thin glass.

(b) For structures underground, such as masonry arches, abutments, retaining walls, foundation walls of buildings, subways, etc., a flow point of 185° Fahr. and a brittle point of 0° Fahr. will be required.

II. PREPARATION OF SURFACE OF STRUCTURE.

leaning letal.

4. (a) Before applying the asphalt to a metal surface, it is imperative that the metal be cleaned of all rust, loose scale and dirt; and, if previously coated with oil, this must be entirely removed. When the asphalting is done during the summer months, between May and September, the clean, dry metal shall be painted with two coats of cold asphalt paint, free from oil, made by thinning pure gum asphalt with benzine, before the hot asphalt is applied. When the asphalting is done during the winter months, this coating will be omitted, but the metal shall be warmed to the satisfaction of the Engineer, before the hot asphalt is poured on. The warming is best accomplished by covering the metal with hot sand, which should be swept back as the hot asphalt is applied.

lasonry.

(b) When waterproofing masonry structures, if the surface cannot be made dry and warm, it should be first coated with the asphalt paint, applied cold. This is particularly necessary for vertical surfaces.

III. APPLICATION OF COATING.

leating sphalt.

5. The asphalt should be heated in a suitable kettle to a temperature not exceeding 450° Fahr. If the temperature should run above 450° Fahr., for any length of time, it will result in "pitching" the asphalt. Before the "pitching" point is reached, the vapor from the kettle is of a bluish tinge, which changes to a yellowish tinge after the danger point is passed. The asphalt has been sufficiently cooked when a piece of wood can be put in and withdrawn without the asphalt clinging to it.

First Coat.

6. (a) The first coat shall consist of a layer not less than ¼ in. thick of pure asphalt poured from buckets on the prepared surface and thoroughly mopped over.

(b) The second coat shall consist of a mixture of clean sand or screenings, free from earthy admixtures, previously heated and dried, and asphalt, in the proportion of 1 asphalt to 3 of sand or screenings by volume; this is to be thoroughly mixed in the kettle and then spread out on the surface with warm smoothing irons, such as are used in laying asphalt streets. Second Coat.

(c) The third or finishing coat shall consist of pure hot asphalt spread evenly in a layer not less than 1/4 in. thick over the entire surface, and then sprinkled with washed roofing gravel, torpedo sand, or stone screenings, to harden the top. Third Coat.

7. (a) The built-up thickness of the three coatings described in Section 5 should be 1½ in. at the thinnest place for steel bridges and 2 in. for masonry arch bridges. Thickness.

(b) This built-up asphalt covering must not perceptibly indent when at a temperature of 130° Fahr., under a load at the rate of 15 lbs. per sq. in., and it must remain ductile at a temperature of 15° Fahr. below zero on metal structures, and at 0° Fahr. on masonry structures under ground. Load Test.

IV. CONCRETE FILLER.

8. In the case of steel trough floors, the trough will first be filled with Portland cement concrete, mixed in the proportions of 1 cement, 3 sand, and 3 broken stone, and the surface will be finished 1½ in. below and to the same shape as the asphalt surface. The concrete is to be placed against the clean steel, free from rust, oil, paint or dirt. A plan for drainage may be necessary in each case, because that is affected by the length and grade of bridge and by the direction of the troughs. Concrete Mixture.

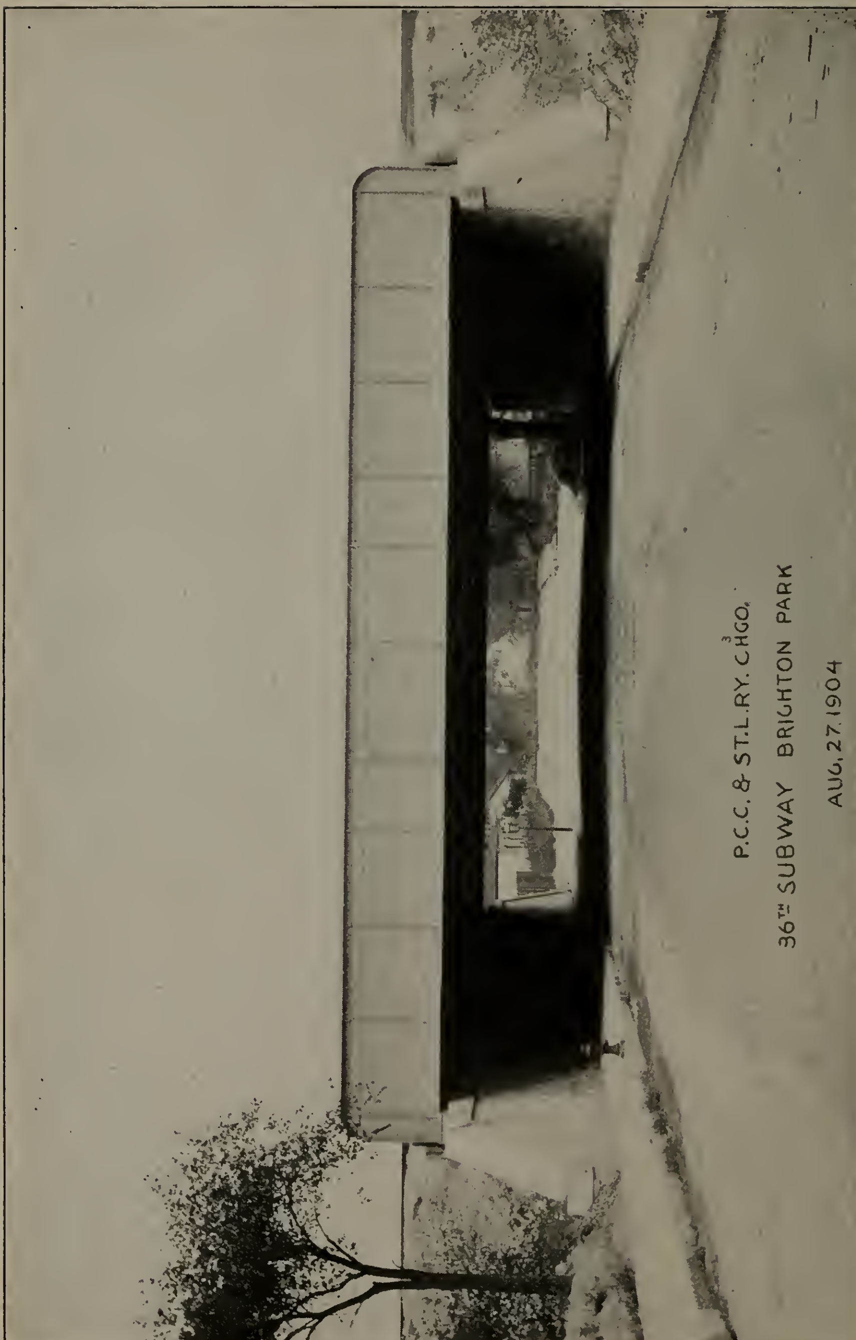
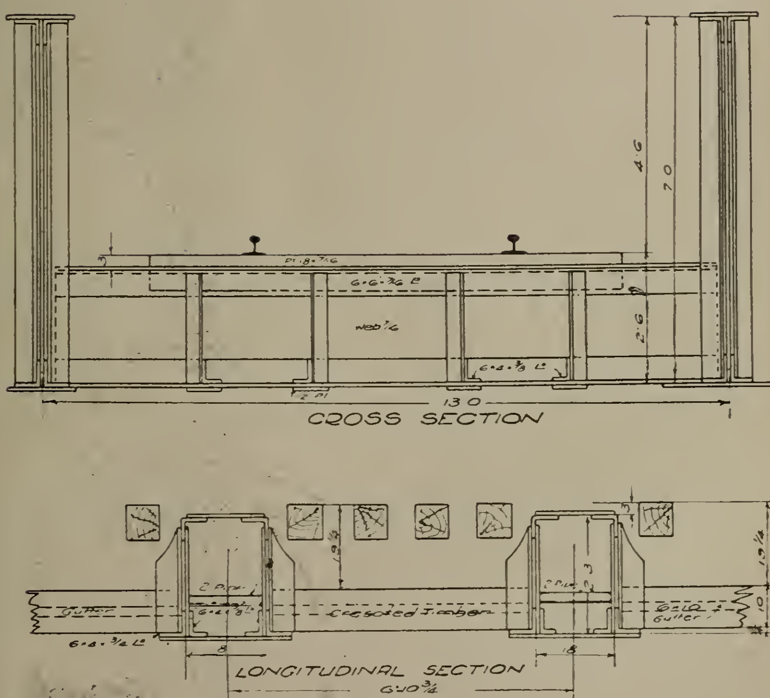


Fig. 1.



35th ST.

Fig. 2.

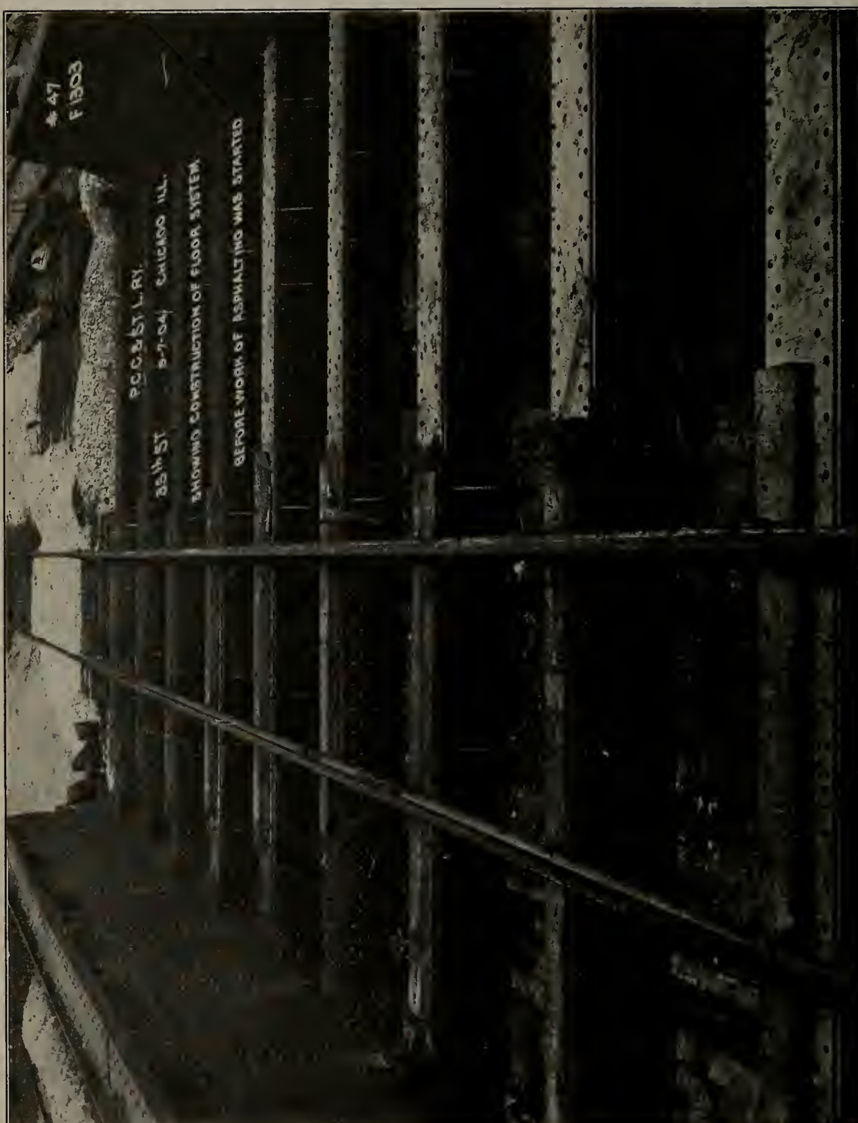

#47
F1303
P.C.C.&St.L.RY.
35th ST. CHICAGO ILL.
5-7-04
SHOWING CONSTRUCTION OF FLOOR SYSTEM
BEFORE WORK OF ASPHALTING WAS STARTED

Fig. 3.

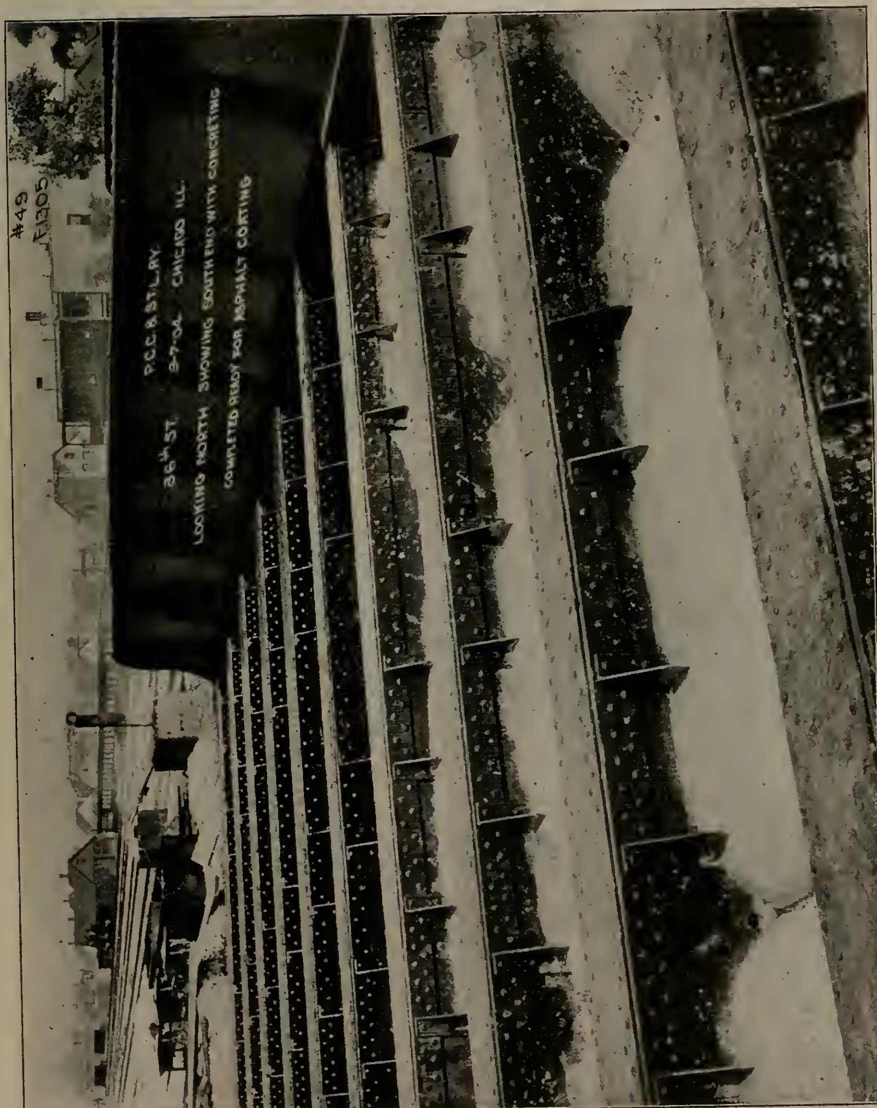

#49
F1305
P.C.C.&ST.L.RY.
36TH ST. 9-7-04 CHICAGO ILL.
LOOKING NORTH SHOWING SOUTH END WITH CONCRETING
COMPLETED READY FOR ASPHALT COATING

Fig. 4.

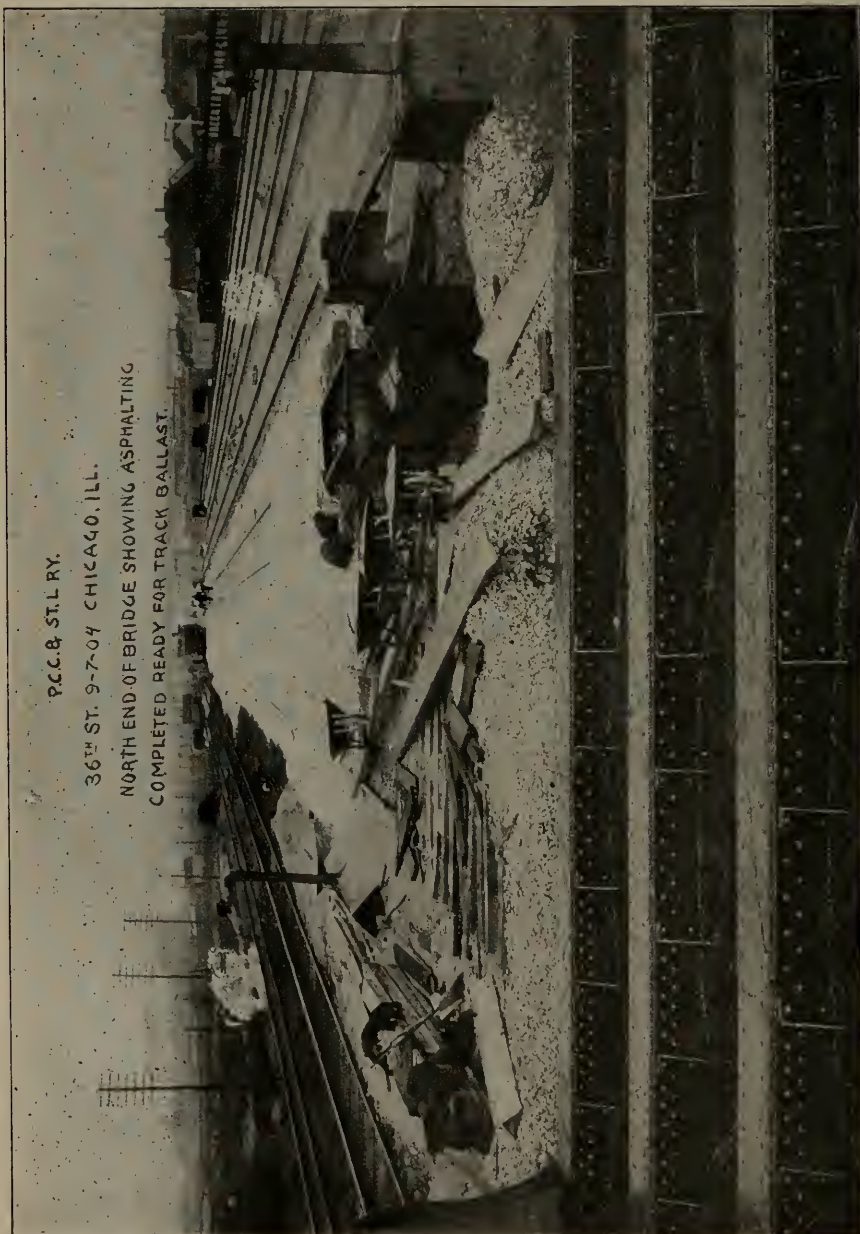

P.C.C.& ST.L RY.
36TH ST. 9-7-04 CHICAGO, ILL.
NORTH END OF BRIDGE SHOWING ASPHALTING
COMPLETED READY FOR TRACK BALLAST.

FIG. 5.

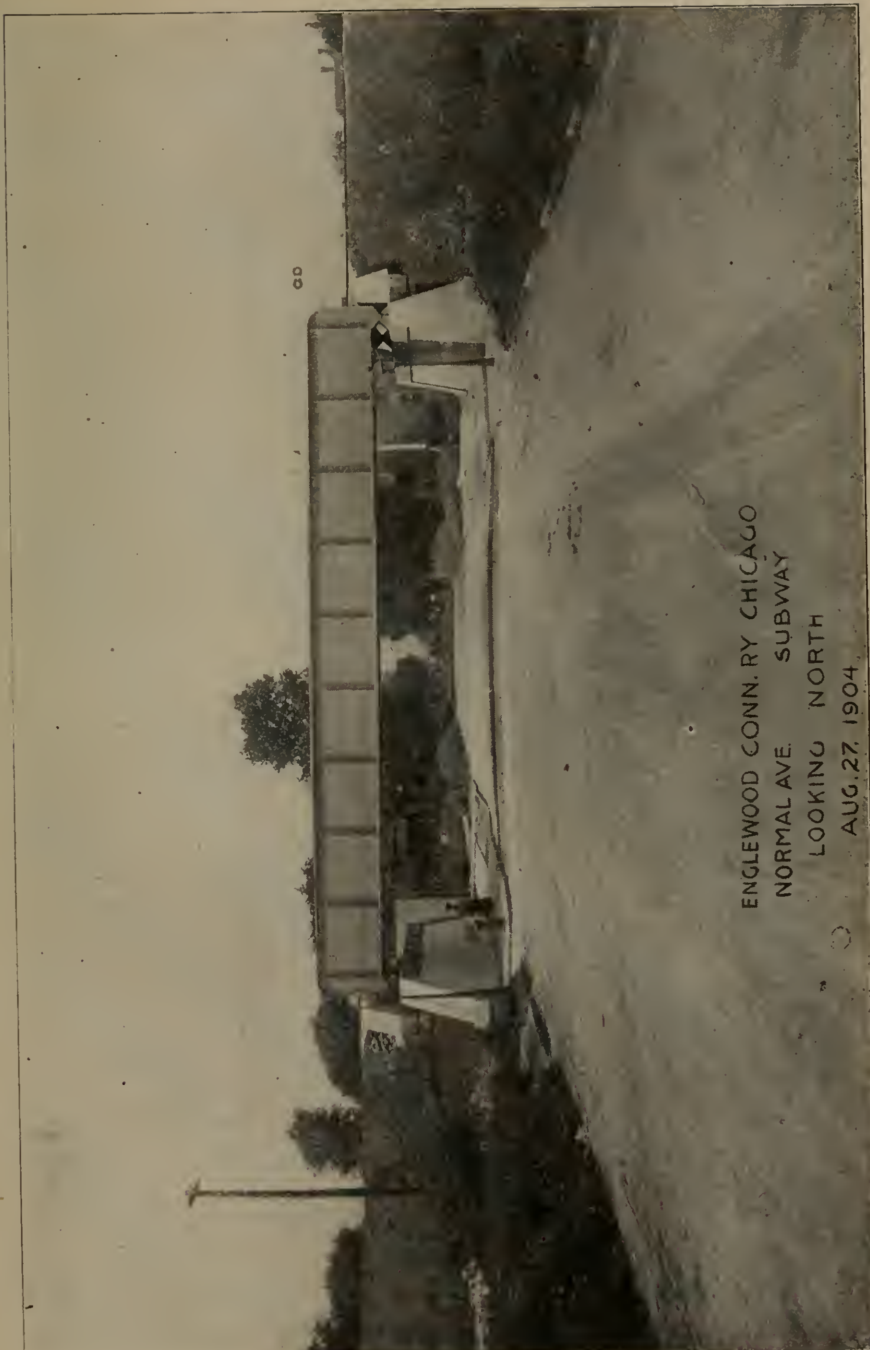
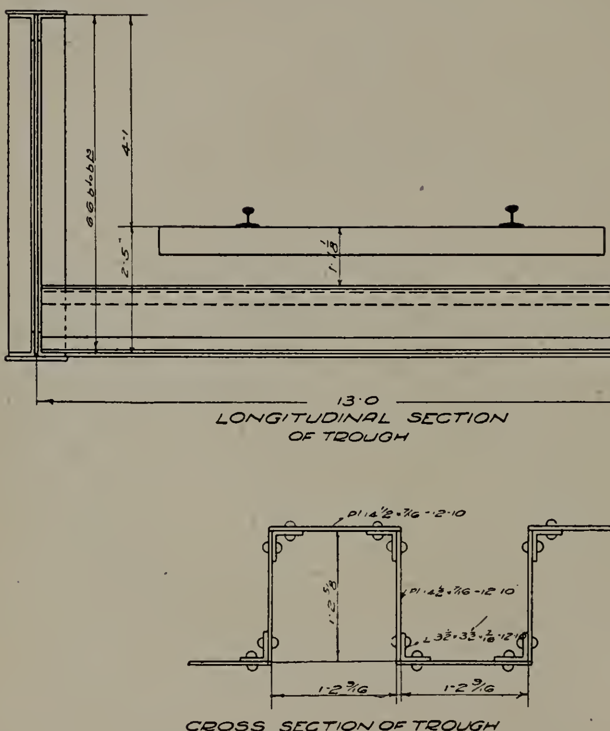


Fig. 6. Normal Ave. or Wright St.



WRIGHT ST

FIG. 7.

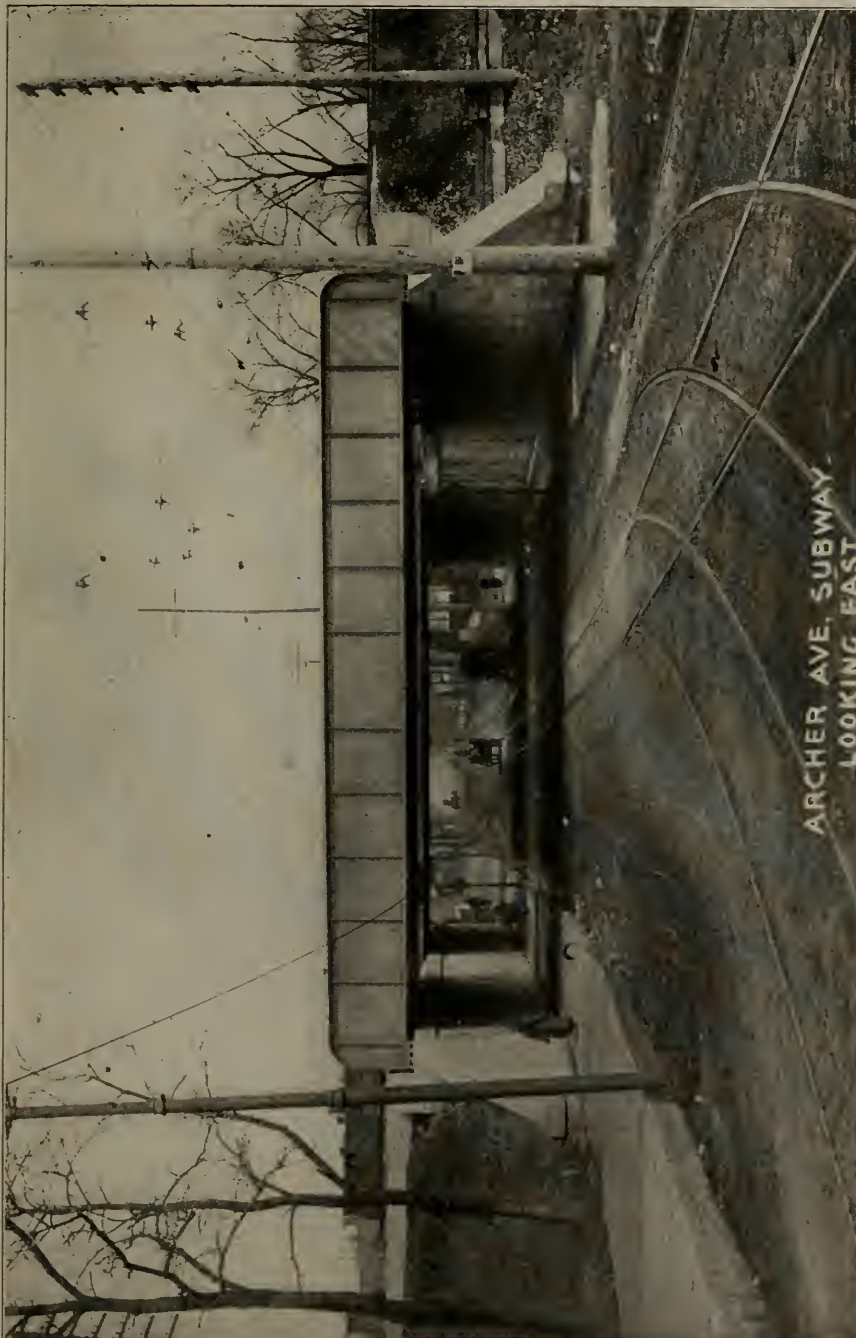


Fig. 8.

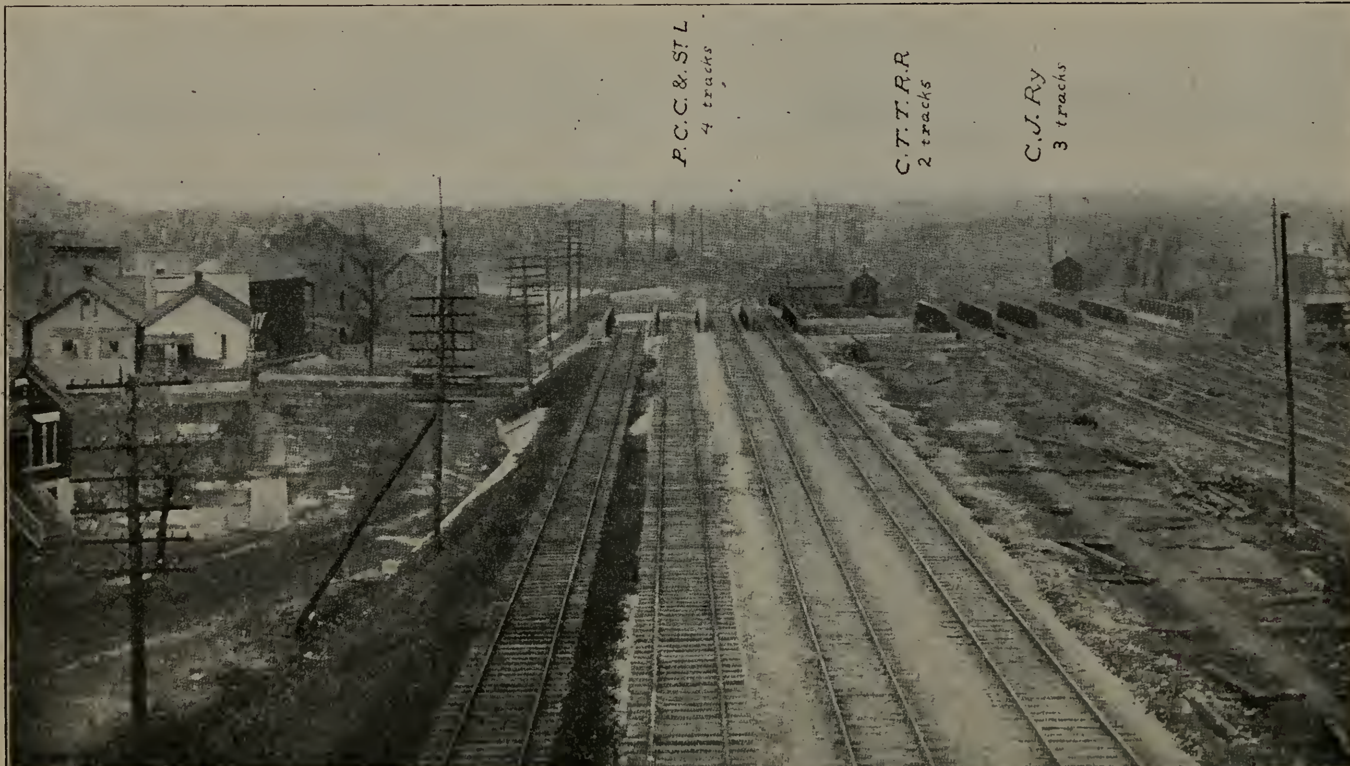


Fig. 9. Archer Ave. Subway—Track View Looking North.


450
F1306
P.C.C.&St.L.RY.
ARCHER AVE 9-7-04. CHICAGO ILL.
SHOWING CONSTRUCTION OF FLOOR SYSTEM
BEFORE WORK OF WATER PROOFING WAS STARTED

FIG. 10.

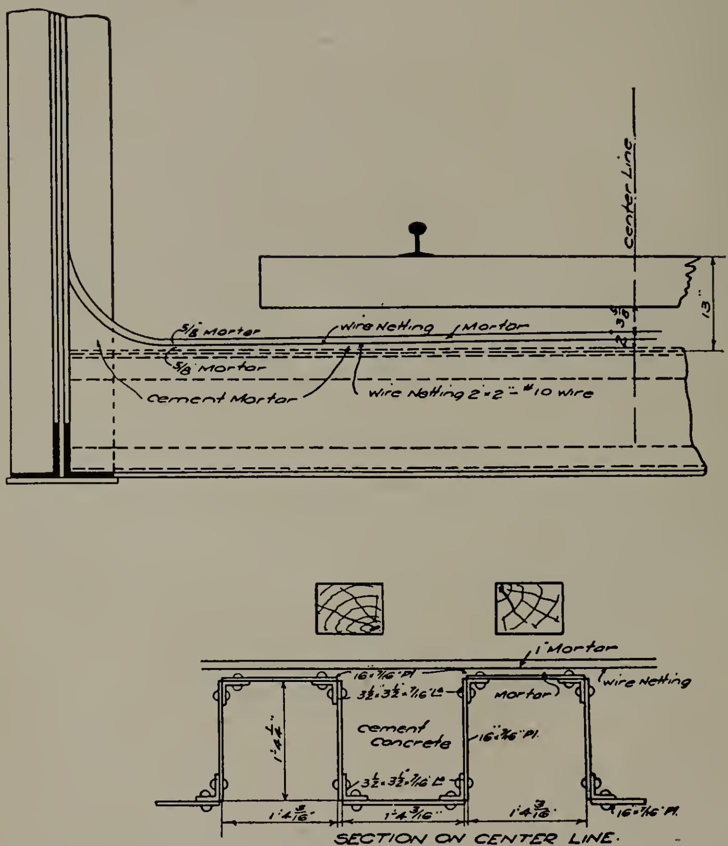


FIG. 11. ARCHER AVE.—WIRE NETTING METHOD.


F.C.COSTLEY CHICAGO, ILL.
ARCHER AVE LOOKING NORTH
WIRE NETTING BEING PLACED
IN POSITION
SEPT 30, 1904
F NO. 1332

FIG. 12.

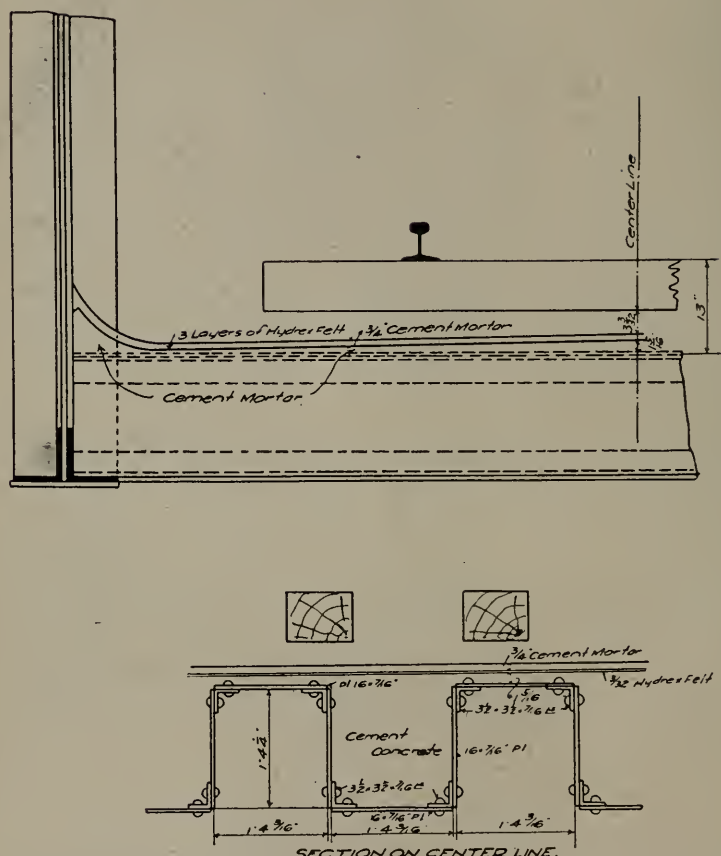


FIG. 13. ARCHER AVE.--HYDREX FELT METHOD, WITH CONCRETE ON TOP.

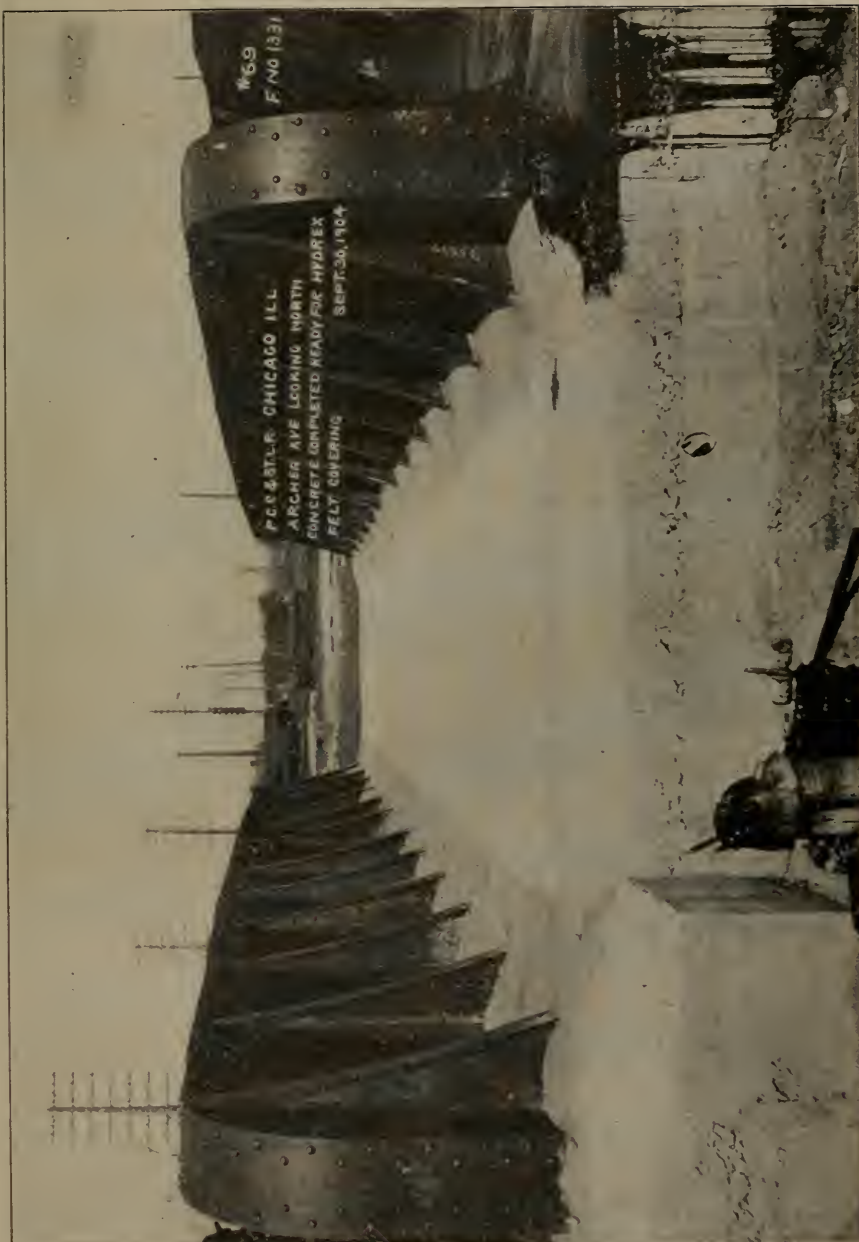

P.C.C.&ST.L.R. CHICAGO ILL.
ARCHER AVE LOOKING NORTH
CONCRETE COMPLETED READY FOR HYDREX
FELT COVERING
SEPT. 30, 1904

FIG. 14.

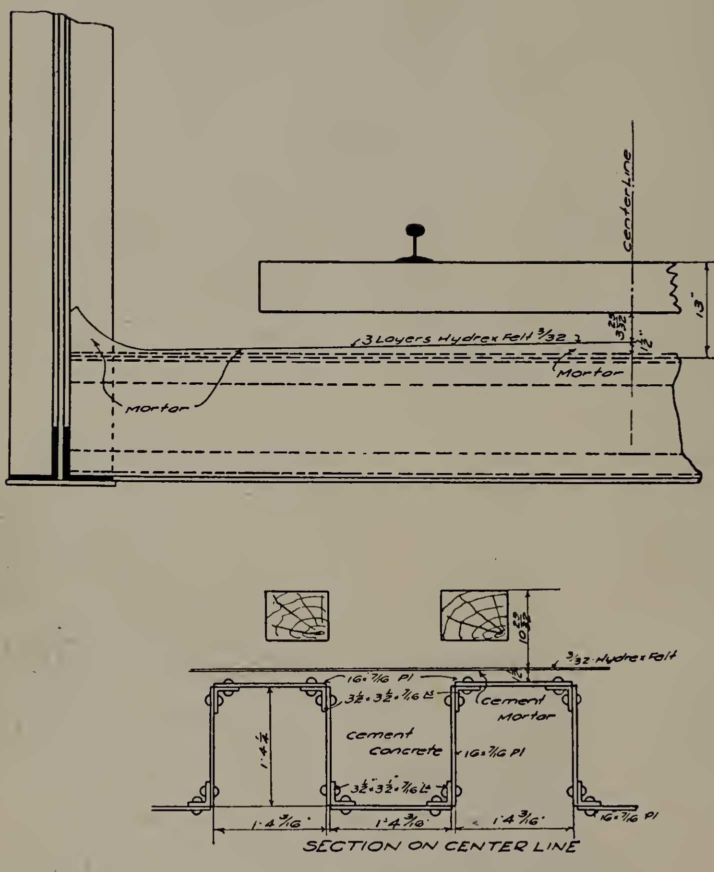


FIG. 15. ARCHER AVE.—HYDREX FELT METHOD.

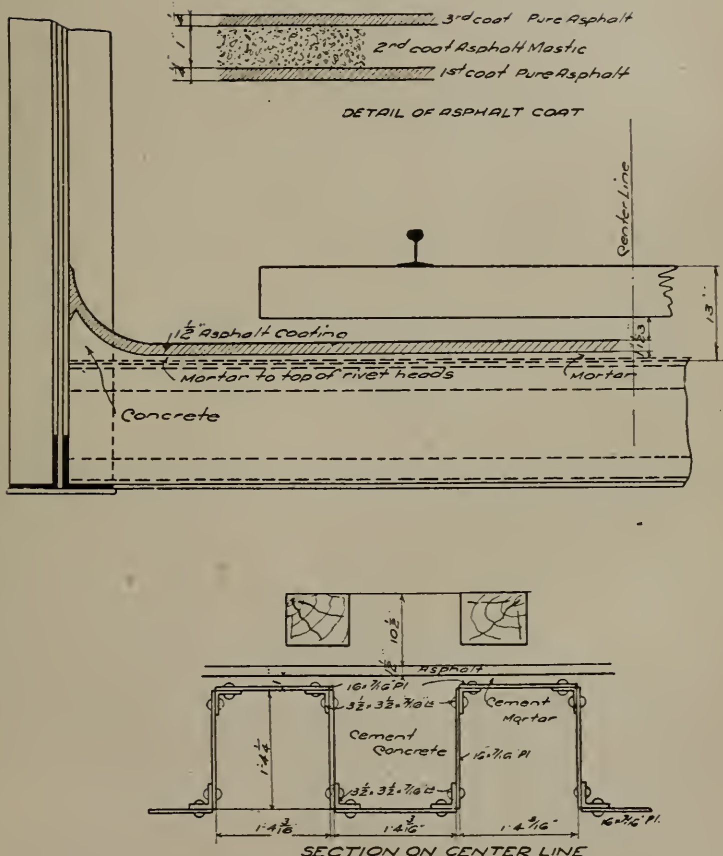


FIG. 16. ARCHER AVE.—ASPHALT METHOD.


#68
No. 1330
P.C.C.&St.L.R. CHICAGO TERM
ARCHER AVE. LOOKING NORTH
CONCRETE COMPLETED AND
1st COAT OF ASPHALT APPLIED
SEPT. 30, 1904

FIG. 17.

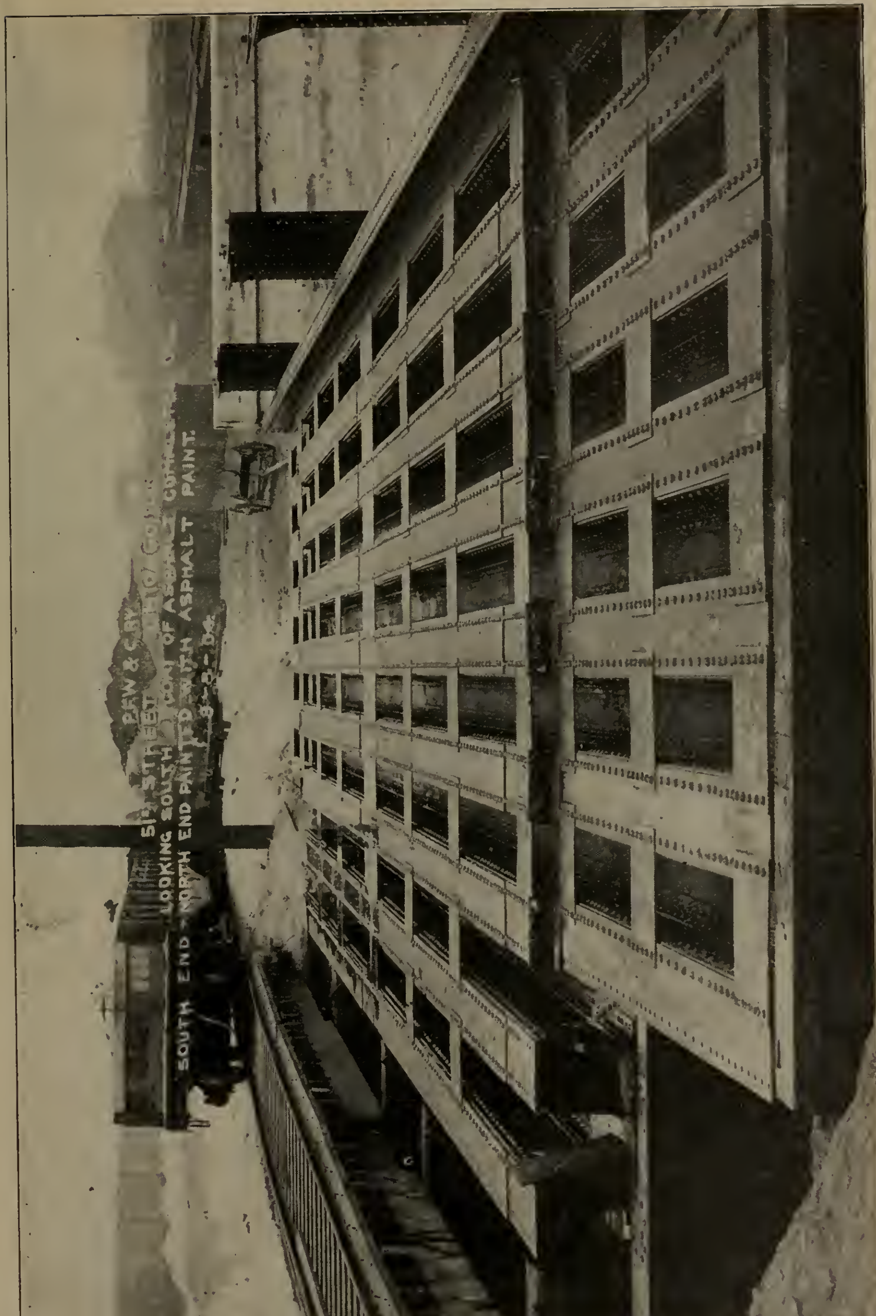

LOOKING SOUTH
OF ASPHALT
SOUTH END
NORTH END PAINTED WITH ASPHALT PAINT

Fig. 18.


No. 118
F1438
51ST STREET SUBWAY
LOOKING WEST FROM EAST HUMP
JAN. 20TH 1905

FIG. 19.


P.F.W.& C. RY.
51ST STREET CHICAGO, ILL.
WATERPROOFING COMPLETED
9-8-04

Fig. 20.

Appendix C.

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"The Action of Water on Asphalts." By George C. Whipple and Daniel D. Jackson. Brooklyn Engineers' Club. Proceedings, 1900, page 80, Brooklyn, 1901. (Results of a series of experiments on refined asphalts.)

Abstracts of same. Eng. News, Vol. 43, page 187; Mineral Industry, Vol. 9, page 51 (1901).

"Asphalt and Brick Reservoir Linings." Eng. Record, Vol. 42, page 315. (A description of a reservoir lining in Steelton, Pa.)

"Specifications for Asphalt Reservoir Linings at Philadelphia." Eng. News, Vol. 35, page 164. (Queen Lane and Roxborough Reservoirs. For each reservoir bids are invited for an asphalt paint lining, with and without the use of burlap, and for a watertight lining under any plan proposed by the bidder. For the Queen Lane Reservoir bids are also wanted for an asphalt-concrete lining.)

"Asphalt Lining for Old and New Reservoirs." By L. J. Le Conte. American Water Works Association. Proc., Vol. 16, page 230. (Gives the results of practical experience and experiments.)

Abstract of same. Eng. News, Vol. 35, page 382.

"Les Chapes Imperméable sur les Ponts en Maçonnerie." By Léon Malo. Revue Générale des Chemins de Fer, Vol. 19, page 48. (Treats of asphalt coating as a protection to stone arches against the infiltration of rainwater.)

Abstract of same. "Impermeable Covering for Stone Arches." Eng. News, Vol. 36, page 143.

"Queen Lane Reservoir, Philadelphia." Eng. Record, Vol. 33, page 258. (Contains specifications for the asphalt lining.)

"The Repairs to the Queen Lane Reservoir, Philadelphia, Pa." Eng. Record, Vol. 35, page 361. (On the results obtained by lining the reservoir with asphalt.)

"Covered Reservoirs." By W. S. Shields. Illinois Society of Engineers and Surveyors, Vol. 15, page 146. (Describes two small covered reservoirs for the cities of Attica and Delphi, Ind.; an attempt was made to use asphalt for waterproofing.)

Abstract of same. "The Attica and Delphi Covered Reservoirs." Eng. Record, Vol. 41, page 274.

"Recent Reservoir Linings." Eng. Record, Vol. 40, page 77. (Details of asphalt linings at Black Hawk, Colo.; Lancaster, Ohio, and Coatsville, Pa.)

"Lining a Reservoir Near Whitby." By George Bramsby Williams. Minutes Proceedings Institution of Civil Engineers, Vol. 137, page 357. (Callendar bituminous sheeting was used in order to make the reservoir lining waterproof.)

Abstract of same. "A Concrete-Asphalt Reservoir Lining." Eng. Record, Vol. 40, page 670.

"A Small Asphalt-Lined Reservoir at Indio, Cal." By J. B. Lippincott. Eng. News, Vol. 36, page 35. (Details of the lining and cost.)

"Asphalts and Bitumens." By Samuel P. Sadtler. Journal, Franklin Institute, Vol. 140, page 198. (Contains a very little information on the uses of asphalt for waterproofing.)

"The Upper Belmont Reservoir at Philadelphia." Eng. Record, Vol. 43, page 501. (Contains details of the composition and placing of the asphalt lining.)

"Notes on Cement and Concrete Construction in the United States Government Fortification Work for 1902." Eng. News, Vol. 49, page 306. (Specifications for waterproofing with asphalt. Also describes the stopping of leaks in concrete construction with linseed oil and with asphaltum and oil.)

"Rock Asphalt and Asphalt Mastic." By Henry Wiederhold. Proc., Engineers' Club of Philadelphia, Vol. 20, page 187. (On the use of asphalt mastic for waterproofing.)

"Technical Details of Engineering Methods on Fortifications, and Rivers and Harbors." In "Annual Report of the Chief of Engineers," 1905, Part 3, pages 3003, 3007, 3032. Wash., 1905, Govt. Printing Office. (Describes waterproofing with coal-tar or asphalt in the defenses of the coasts of Maine and New Hampshire, defenses of the Delaware River, defenses of the mouth of the Columbia River.)

"Technical Details of Engineering Methods on Fortifications, Rivers and Harbors, and Other Works." In Annual Report of the Chief of Engineers, 1904, Part 4, pages 3709, 3713, 3718, 3719, 3721, 3724, 3725, 3728, 3729, 3730, 3732, 3737. Wash., 1904, Govt. Printing Office. (Damp proofing with different forms of coal-tar or asphalt in defenses of the coast of Maine, at the eastern entrance to Long Island Sound; hydrolene applied to concrete surfaces; defenses at Fort Totten, N. Y.; asphalt a failure in damp proofing at Battery Anderson, Va.; details of waterproofing at Battery Brumby, Fort Screven, Ga.; defenses of the coast of Florida; defenses of Mobile, Ala.; defenses of Galveston, Texas; examples of waterproofing roofs.)

"Technical Details of Engineering Methods on Fortifications, Rivers and Harbors." In Annual Report of Chief of Engineers, 1903, Part 4, pages 2379, 2387, 2390, 2399, 2406, 2408, 2410, 2411, 2412, 2413, 2416, 2421. Wash., 1903, Govt. Printing Office. (Cork lining for waterproofing was stuck to the walls by a special preparation of asphaltum; defenses at eastern entrance to Long Island Sound, damp proof concrete surfaces with coal-tar; coal-tar and asphalt used in defenses of New York Harbor; Washington, D. C.; Fort Screven, S. C.; coal-tar and asphalt used in South Carolina; defenses on the coast of Florida, and of San Francisco Harbor.)

"Technical Details of Engineering Methods on Fortifications, Rivers and Harbors." In Annual Report of Chief of Engineers, 1902, Part 3, pages 2463, 2466, 2467, 2469, 2473, 2474, 2478, 2485, 2487, 2488, 2494, 2482. Wash., 1902, Govt. Printing Office. (The use of coal-tar and asphalt for waterproofing defenses of Baltimore; Pensacola, Fla.; Mobile, and Mississippi Sound; San Francisco, Cal.; mouth of the Columbia River; Oregon, and Washington.)

"Fortifications." In Annual Report of the Chief of Engineers, 1901, Part 1, pages 868, 912, 918, 923, 924. Wash., 1901, Govt. Printing Office. (Details of the use of coal-tar and asphalt for waterproofing.)

"Fortifications." In Annual Report of the Chief of Engineers, 1900, Part 1, pages 760, 775, 809, 815, 816, 824, 898, 931, 944, 946, 978, 982, 1013, 1025. Wash., 1900, Govt. Printing Office. (The use of asphalt P. and B. paint and tar paper for waterproofing batteries, etc.)

"Fortifications." In Annual Report of the Chief of Engineers, 1899, Part 1, page 798. Wash., 1899, Govt. Printing Office. (Asphalt was used for waterproofing the battery.)

"Fortifications." In Annual Report of the Chief of Engineers, 1898, Part 1, pages 645, 652, 679, 680, 727. Wash., 1898, Govt. Printing Office. (Asphalt, etc., were used for waterproofing.)

"Fortifications." In Annual Report of the Chief of Engineers, 1897, Part 1, page 735. Wash., 1897, Govt. Printing Office. (Asphalt and coal-tar were used for waterproofing.)

Abstract of Annual Report of the Chief of Engineers, 1904. "Waterproofing Concrete on United States Fortification Work." By Emile Low. Eng. News, Vol. 56, page 252.

Abstract of Annual Report of the Chief of Engineers, 1905. "Experiences in Waterproofing Concrete, United States Fortification Work." Eng. News, Vol. 55, page 302.

"Waterproof Cellar Construction." By Colbert A. MacClure. Proc., Engineers' Society of Western Pennsylvania, Vol. 23, page 517. (A comparison between the use of paper or felt as a vehicle for liquid tar, asphalt "Hydrex," etc., and the use of hydrolithic cement for waterproofing.)

"Coal-Tar Paint." By A. C. Cunningham. Journal of the American Society of Naval Engineers, Vol. 18, page 604.

Abstracts of the same. Eng. News, Vol. 56, page 46; Journal of Gas Lighting, Vol. 95, page 641.

"A Method of Mixing and Laying Bituminous Concrete for Mill Floors." By C. H. Chadsey. Eng. News, Vol. 56, page 118. (Describes the making of a floor of tar concrete to resist moisture.)

"Waterproofing Coast Defense Structures." Eng. News, Vol. 58, page 117. (Abstracts from advance papers of the report of the Chief of Engineers, U. S. A.)

Water-Tightness. In "A Treatise on Concrete, Plain and Reinforced," page 338. By Frederick W. Taylor and Sanford E. Thompson. Ed. 2, New York, 1905. (On the use of coal-tar and asphalt for waterproofing and specifications for the New York Subway.)

Asphalt Waterproofing. In "Concrete and Reinforced Concrete Construction," page 145. By Homer A. Reid, 1907. Myron C. Clark Publishing Company. (Contains five pages on the subject, giving costs.)

"Handbook of Cost Data," pages 293, 591. By Halbert P. Gillette, 1906. Myron C. Clark Publishing Company. $3.60. (Abstracts from papers in the Transactions, American Society of Civil Engineers, on the cost of asphalt for reservoir linings.)

Damp-Resisting Paints. In "The Chemistry and Technology of Mixed Paints," page 123. By Maximilian Toch. New York, 1907. (Contains one page making general statements on waterproof paints.)

"The Design of Steel Mill Buildings," pages 257, 284, 339. By Milo S. Ketchum. Ed. 2. New York, 1906. Eng. News. (Contains specifications for asphalt roofing, coal-tar or asphalt concrete floors, asphalt and coal-tar paints.)

"Cassell's Building Construction," pages 53, 70, 260. By Henry Adams. London, 1906. (Contains short paragraphs on the use of asphalt for waterproofing foundations, floors and roofs.)

"Cement and Concrete," pages 457, 458, 467, 469, 472. By Louis Carlton Sabin. Ed. 2, New York, 1907. McGraw Pub. Co. (Contains specifications for waterproof construction of the New York Subway, details of the Boston Subway, and reservoir linings.)

"Specifications for the New Waterside Power House of the New York Edison Company, New York, July, 1907," pages 20, 65. New York, 1907. (Specifications for waterproofing with a layer of asphalt.)

"Boston Transit Commission, Annual Report, 6th" (1900), page 30. Boston Transit Commission. (Three thicknesses of tarred felt were used for waterproofing.)

Abstract of same. "The East Boston Tunnel Extension of the Boston Subway." Eng. News, Vol. 45, page 242.

"Asphalts, Their Sources and Utilization." By T. Hugh Boorman. Architects' and Builders' Magazine, Vol. 3, pages 83, 128, 201, 430. (A general article.)

"Report of the Board of Rapid Transit Railroad Commissioners for and in the City of New York up to December 31, 1901," pages 191, 249; facing pages 189, 191, 226, 249. New York, 1902. Board of Rapid Transit Railroad Commissioners. (Gives the method of waterproofing the subway. Illustrated.)

Same. Report for 1902, page 234. (The statement is merely made that "Full precautions were taken to prevent the percolation of water into the finished structure by reinforcing the ordinary waterproofing layer of felt and asphalt with courses of brick laid in hot asphalt.")

"Asphaltum in 1893," page 13. By Clifford Richardson and E. W.

Parker. (Extract from Mineral Resources. Contains very brief data on waterproofing.)

"Lecture on Asphalt." By Henry Wiederhold. New York, 1904. Vulcanite Portland Cement Co. (On the use of asphalt mastic for waterproofing.)

"Bitumen; Its Varieties, Properties and Uses." By Lieut. H. Wager Halleck. Wash., 1841. (On the use of asphalt for waterproofing.)

"Naturlichen Asphalt, seine Anwendung und Bearbeitung bei Bauwerken." By Diedrich Heinrich Henning. Hanover, 1866.

'Note sur les Chapes de Voutes en Mastic Bitumineux de Seyssel a l'Epreuve de la Bombe." By P. Coignet. Paris, 1875. Gauthier-Villars, 55 Quai des Augustins. (The use of asphalt for waterproofing fortifications.)

"The Four New Reservoirs for the Water-Works of Portland, Ore." By James D. Schuyler. Eng. News, Vol. 32, page 399. (The surface of the concrete lining is coated with California asphalt.)

"Specifications for the Boston Subway." Eng. Record, Vol. 34, page 273. (Water-tight work is required, and to this end the whole exterior of the top and side walls shall be thoroughly coated with a smooth layer at least ¾ in. thick of roofing pitch or similar material.)

"Asphalt and Its Uses." By F. V. Greene, Trans., American Institute of Mining Engineers, Vol. 17, page 364. (Contains two pages on the use of refined asphalt for waterproofing; also contains details of the preparation of asphalt.)

"Waterproofing Ballasted Bridge Floors at Schenectady, N. Y." Eng. Record, Vol. 57, page 371.

"Elevation of Tracks in Wilmington," Street Railway Journal, Vol. 29, page 471. (One paragraph on waterproofing the concrete with five layers of felt and asphalt compound.)

"Waterproof Engineering." By Edward W. DeKnight. Journal, Association Engineering Society, Vol. 39, page 319.

"New Yards and Terminal Approaches at Washington, D. C." By W. S. Strouse. Railroad Gazette, Vol. 37, page 539. (Over the solid mass of steel and concrete of the bridge floors is a layer of petroleum residuum ¾ in. thick, and on top of that is another layer of reinforced concrete on which the ballast is laid.)

"Atlantic Avenue Improvement, Viaduct, Division No. 2." By James B. French. Trans., Association of Civil Engineers, Cornell University, Vol. 12, page 11. (Specifications for filling and waterproofing troughs of shallow floors with asphalt and asphalt concrete.)

Abstract of same. "The Atlantic Avenue Improvement of the Long Island Railroad in Brooklyn, N. Y. Eng. News, Vol. 47, page 419.

"The Hudson and Manhattan Tunnel System." By J. Vipond Davies. Railroad Gazette, Vol. 47, page 747. (Tunnel was waterproofed with one of the usual types of waterproofing compound and neat Portland cement.)

"Tunnel Waterproofing, Franklin & Clearfield Railroad." Eng. Rec-

ord, Vol. 60, page 190. (The mortar lining of the masonry arch was covered with alternate layers of coal-tar pitch and roofing felt.)

"A Concrete Church and the Methods of Waterproofing It." Eng. Record, Vol. 60, page 468. (For the purpose of waterproofing Limoid was mixed with the ¾-in. mortar coat, and in addition the interior of the monolithic walls was given two coats of waterproofing compound before applying the plaster; the compound was manufactured by the Germania Roofing Company of New York City.)

"Unusual Cellar Waterproofing." Eng. Record, Vol. 60, page 468. (The surface of the excavation was covered with about 3 in. of hand-mixed concrete covered with five-ply waterproofing flashed up to a height of over 5 ft. on exterior walls.)

"Permeability Tests of Concrete with the Addition of Hydrated Lime." By Sanford E. Thompson. Proc., American Society for Testing Materials, Vol. 8, page 500 (1908). (Results of tests made of method of making concrete water-tight.)

Abstract of same. "Tests to Determine the Effect of Addition of Hydrated Lime on the Water-Tightness of Concrete." Engineering-Contracting, Vol. 30, page 42.

"Waterproofing Cement Mortars and Concretes; The Asphalt Mastic Method." By H. Weiderhold. Proc., National Association of Cement Users, Vol. 3, page 228. (Experience with the use of asphalt mastic and methods of using it.)

"Waterproofing Cement Mortars and Concretes; The Elastic vs. the Rigid Method." By Edward W. DeKnight. Proc., National Association of Cement Users, Vol. 3, page 238. (Recommends a strong fibrous felt.)

"Waterproofing Cement Mortars and Concretes; The Dry Compound Method." By R. R. Fish. Proc., National Association of Cement Users, Vol. 3, page 249 (1907). (Recommends a waterproof compound, which is mixed dry with cement before sand and water are added.)

"Waterproofing Concrete." By W. H. Finley. Proc., National Association of Cement Users, Vol. 1, page 35. (Gives specifications for the use of asphalt for waterproofing.)

Abstracts of same. "Waterproofing Concrete Structures." Eng. Record, Vol. 51, page 66; Municipal Engineering, Vol. 28, page 140.

"Making Concrete Waterproof." By Ira O. Baker. Technograph, No. 23, page 49. (Tests of alum and soap waterproofing.)

Abstract of same. Eng. Record, Vol. 60, page 413.

"Review of Methods of Waterproofing Concrete Structures." By C. G. Derick. Technograph, No. 23, page 55. (Tests of waterproofing made by adding by mechanical mixing foreign material and neat cement and sand.)

"Foundation Waterproofing in the State Education Building." Eng. Record, Vol. 60, page 440.

"Waterproofing Cement Mortars and Concretes; The Liquid Method." By G. G. Fry. Proc., National Association of Cement Users, Vol. 3, page 255. (Recommends a waterproofing paint.)

"Waterproofing Cement Mortars and Concretes; The Hydrocarbon

Paint Method." By S. J. Binswanger. Proc., National Association of Cement Users, Vol. 3, page 257. (Discusses the use of hydrocarbon paint for damp proofing.)

"Waterproofing; Various Applications and Comparative Costs." By T. Hugh Boorman. Proc., National Association of Cement Users, Vol. 5, page 143. (Considers bituminous waterproofing, applied when hot; the application of cold asphalt materials, and the use of a dry compound for waterproofing, added to the hydraulic cement mixture; gives specifications for waterproofing of bridges in the District of Columbia, and method of waterproofing in connection with track elevation of the Philadelphia & Reading Railway in Philadelphia.)

"Repairs to the Lining of a Small Reservoir on Powder Horn Hill, Chelsea, Mass." By Caleb Mills Saville. Journal, New England Water Works Association, Vol. 19, page 66. (The lower layer of concrete in the reservoir lining was coated with asphalt in order to make the work water-tight.)

"The Waterproofing of the Land Sections of the Detroit-River Tunnel." By Stacey H. Opdyke. Eng. News, Vol. 60, page 335. (The tunnels are rendered waterproof by a complete envelope of coal-tar pitch and felt saturated with coal-tar; specifications are given.)

"Tests on Waterproofing Qualities of Clay and Alum in Cement." Eng. News, Vol. 60, page 373. (Results of tests made by the Delaware & Ulster Railroad Co.)

"Effect of Clay on Concrete." By H. W. McGee. Eng. Record, Vol. 58, page 364. (Tests made for the Ulster & Delaware Railroad.)

"Waterproofing Under Difficult Conditions." Eng. Record, Vol. 58, page 459. (Waterproofing with a coat of cement mortar mixed with bitumen emulsion.)

"Waterproofing Concrete." By M. S. Crayton. Eng. Record, Vol. 58, page 392. (Recipe for waterproofing, stated by the editor to be a modification of the Sylvester wash.)

"Waterproofing of Concrete Covered Steel Floors of Bridges; Report of Committee." American Railway Bridge and Building Association. Proc., Vol. 18, page 46. (Gives current practice in waterproofing of a number of different railroads, and specifications prepared by W. H. Finley.)

Abstracts of same. "Current Methods of Waterproofing Concrete Covered Bridge Floors." Eng. Record, Vol. 58, page 488; Eng.-Contr., Vol. 30, page 288.

"Erection and Waterproofing of Plate Girder Bridges at Plainfield. N. J." Eng. Record, Vol. 57, page 134. (The waterproofing consists of Hydrex felt and waterproofing compound.)

"Sulphate of Alumina for Waterproofing Concrete." By F. B. Edwards. Eng. Record, Vol. 57, page 820. (Also gives answer by Alfred D. Flinn, New York, Board of Water Supply.)

"The Waterproofing of Concrete." By Myron H. Lewis. Eng. News, Vol. 59, page 176. (Discusses waterproofing with compounds.)

"The Effect of Alum and Clay in the Waterproofing of Concrete." By Samuel A. Brown. Eng. News, Vol. 59, page 260.

"Tests of Effect of the Addition of Clay and Alum Solution on the Tensile Strength and Impermeability of Mortar." By M. H. McGee. Eng.-Contr., Vol. 30, page 186. (Experiments conducted by the Ulster & Delaware Railroad.)

"The Use of Asphaltum." By Harry Larkin. Journal, Association of Engineering Societies, Vol. 41. page 292. (Method of preparing asphaltum for waterproofing and other uses.)

"Substructure of the New Meier & Frank Building." By H. E. Plummer. Eng. Record, Vol. 60, page 148. (The waterproofing was three layers of tarred felt, alternating with two layers of burlap, all laid with Sarco compound.)

"Waterproofing." By J. L. Mothershead, Jr. Proc., National Association of Cement Users, Vol. 1, page 159. (Contains no definite data.)

"Modern Tunnel Practice," page 240. By David McNeely Stauffer. 1906. Eng. News. (Contains data on different methods of waterproofing masonry.)

"N. Y. C. & H. R. R. Co. Standard Specifications." (States that waterproofing for tunnels shall consist of five-ply No. 28 Tar-Roofing Felt, mopped together with straight run coal-tar pitch.)

"Detroit River Tunnel Between Detroit, Michigan, and Windsor, Canada. Invitation, Proposal, Specifications, Contract, Bond and Permits," page 27. Detroit River Tunnel Company, Grand Central Station. (Specifications for waterproofing; the ingredients specified, straight run coal-tar pitch, felt or burlap.)

"Pennsylvania, New York & Long Island Railroad, East River Division. Specifications and Contract," page 79. (Specifications for waterproofing in East River Tunnel consist of Hydrex felt and straight run coal-tar pitch.)

Abstract of same. "The P. R. R. Tunnel Under the North River at New York City." Eng. News, Vol. 50, page 334.

"Pennsylvania, New York & Long Island Railroad, North River Division. Specifications and Contract," page 67. (Specifications for waterproofing Hudson River Tunnel are practically the same as those for the East River Tunnel.)

"Pennsylvania, New Jersey & New York Railroad, North River Division. Specifications and Contract," page 68. Pennsylvania Railroad Company. (Specifications for waterproofing in various sections of tunnels under Bergen Hill and Hudson River practically the same as those for the East River Division.)

"Investigations of Permeable Concrete by the Laboratory of the Board of Water Supply, New York City." By James L. Davis. Eng.-Contr., Vol. 29, page 120. (Tests of waterproofing.)

"On the Use of Asphalt and Mineral Bitumen in Engineering." By William Henry Delano. Proc., Institute of Civil Engineers, Vol. 60, page 262 (1879-80). (The use of asphalt for waterproofing.)

"The Construction of Moisture-Proof Underground Chambers." By L. R. Grabill. Eng. News, Vol. 44, page 166. (A description of works waterproofed with asphalt; also describes method of construction of chambers to prevent condensation.)

Eng. News, Vol. 50, pages 225, 294. (Gives description of method of waterproofing the Egyptian obelisk, Central Park, New York, by means of melted paraffine.)

"Experiences in Waterproofing Concrete." Eng. News, Vol. 55, page 302. (Describes method of waterproofing masonry of coast defense with hydrolene and tarred paper, and also with tarred paper and coal-tar pitch.)

"Difficult Waterproofing of a Concrete Passenger Subway Under Railroad Tracks." Eng. News, Vol. 55, page 409. (Describes the "Hydrex" method as applied to foot passenger subway under tracks of South Side Railroad at the Metropolitan Race Track at Jamaica, Long Island, N. Y.)

"Waterproofing Concrete Roofs; San Francisco Harbor Fortification Work." Eng. News, Vol. 55, page 473. (Describes method of waterproofing concrete roofs of harbor batteries with asphalt mastic and roofing felt.)

"Waterproofing Concrete and Masonry." Eng. News, Vol. 57, page 187. (Gives extract of paper read November 21, 1906, before Western Society of Civil Engineers, by Edward W. DeKnight.)

"Reinforced Concrete Standpipe at Attleboro, Mass." Eng. News, Vol. 57, page 212. (Describes the "Sylvester" system (soap and alum) of waterproofing as applied on this work. Information for this article was mostly taken from paper read by George H. Snell before the New England Waterworks Association.)

"Waterproofing at the Subway Power House, New York." Eng. Record, Vol. 53, page 182 (1906). (Describes the "Winslow" method as applied to basement walls of 59th Street Power House, Interborough Rapid Transit Co., New York.)

"Waterproofing the Substructure of the West Street Building, New York." Eng. Record, Vol. 53, page 601. (Describes method used for waterproofing the building foundation and basement floors.)

"A Thirty-three-Track Bridge at Chicago." Eng. Record, Vol. 53, page 732. (Describes the "Hydrex" system of waterproofing as applied to 51st Street Subway, Chicago, Ill., under the Erie Railroad.)

"The Importance of Waterproofing." Eng. Record, Vol. 52, page 55. Editorial.

"Experiments in Waterproofing Solid Floor Bridges." Eng. Record, Vol. 52, page 161. (Describes some of the problems encountered in this particular branch of engineering work.)

"Waterproofing Brick Arches." Eng. Record, Vol. 52, page 603. (Gives a short description of the "Hydrex" method as applied to the viaduct of Pennsylvania Railroad at Wilmington, Del.)

"Notes and Comments." Eng. Record, Vol. 49, page 603. (Gives some notable examples of the value of coal-tar pitch as a waterproofing material.)

"Waterproofing a Dry Well in a Pumping Station, San Francisco, Cal." Eng. Record, Vol. 50, page 239. (A short description of waterproofing with asphaltum.)

"Sulphate of Alumina for Waterproofing Concrete." Eng. Record, Vol. 57, page 820. (Gives short discussion of the merits of this material for waterproofing purposes.)

"The New York Tunnel Extension of the Pennsylvania Railroad. The Bergen Hill Tunnels." By F. Lavis. Trans., A. S. C. E., Vol. 68, page 140. (The waterproofing in these tunnels was of felt and pitch. The article describes the actual application of materials.)

"The New York Tunnel Extension of the Pennsylvania Railroad. The North River Tunnels." By B. H. M. Hewett and W. L. Brown. Trans., A. S. C. E., Vol. 68, page 197. (Same materials as above; describes difficulties in applying and gives cost of labor.)

"Progress Report of Special Committee on Concrete and Reinforced Concrete." Trans., A. S. C. E., Vol. 66, page 444. (Mentions various methods of waterproofing.)

"Cause and Prevention of the Decay of Building Stone." By Thomas Egleston. Trans., A. S. C. E., Vol. 15, page 698. (Contains data on waterproofing masonry by applying oil, paint, paraffine, asphalt, etc.)

"Progress Report Upon Waterproofing Masonry." American Railway Engineering and Maintenance of Way Association, Bulletin 119, page 115. (Presents replies to inquiries sent out as to methods and effectiveness of systems of waterproofing.)

Abstract of same. "Waterproofing Masonry and Bridge Floors." Eng. Record, Vol. 61, page 361.

"The Waterproofing of Extensive Railroad Bridge Floors." Eng. Record, Vol. 61, page 647 (May 14, 1910). (Waterproofing with Sarco, burlap, covered by sand mastic.)

"Silicate of Soda as Waterproofing for Concrete." Mun. Eng., Vol. 35, page 380. (Gives chemical action of silicate of soda and stone or cement.)

"Waterproof Concrete and Waterproofing Concrete." Mun. Eng., Vol. 36, page 42. (Advocates the production of an impervious concrete block.)

"Aquabar for Waterproofing." Mun. Eng., Vol. 38, page 286. (Brief paragraph.)

"Waterproofing a Reservoir." Mun. Eng., Vol. 38, page 215. (Brief description of use of Pioneer reservoir waterproofing asphalt.)

"Imperial Waterproofing." Mun. Eng., Vol. 38, page 365. (A new material.)

"The Moore Waterproofing System of Masonry." American Gas Light Journal, Vol. 93, page 394. (A method of applying waterproofing by compressed air machines which has been used in the Pennsylvania Railroad and Hudson River Tunnels.)

"Waterproofing of Engineering Structures." By Joseph H. O'Brien. Journal, Association of Engineering Societies, Vol. 44, page 292. (A description of actual work done in New York City with pitch and felt.)

"Effect of Sodium Silicate on Concrete." By Albert Moyer. Eng. Record, Vol. 62, page 104. (Experiments made with sodium silicate.)

Same. Eng.-Contr., Vol. 34, page 3.

"Resistance of Cements to Sea Water Increased by Admixtures of

Puzzuolana." By M. R. Feret. (Tr. by W. Michaelis, Jr.) Cement and Eng. News, Vol. 22, page 11. (An argument for the use of puzzuolanas, trass, santorin earth, or pulverized blast furnace slags.)

"A Simple Method of Testing Damp-proofing Materials." Eng. Record, Vol. 61, page 279. (Tests of articles on the market which did not withstand water or the weather.)

"Results of Tests Made by the Louisville Sewer Commission to Determine Impermeable Mixtures for Concrete." Eng.-Contr., Vol. 33, page 516. (Tests with clay, fine sand, hydrated lime, Medusa, Maumee, McCormick, etc.)

"Investigations on Waterproofing Concrete by the American Society for Testing Materials." Eng.-Contr., Vol. 34, page 49. (Report of Subcommittee concerning the waterproofing of cement by the incorporation of foreign substances, and brief mention of the work of Sub-committee B concerning exterior applications.)

"Possible Use of Mineral Oils Mixed with Concrete." By Albert Moyer. Eng. Record, Vol. 61, page 10. (Records tests made to determine the amount of absorption of water by concrete after having been mixed with oil.)

Same. "Reducing Contraction and Absorption of Concrete by Mixing it with Mineral Oil." Eng.-Contr., Vol. 33, page 26 (January 12, 1910).

"Concrete in Waterworks Construction." By William Curtis Mabee. Proc., American Water-Works Association, Vol. 29, page 655. (A few paragraphs mentioning different methods of waterproofing.)

Same. Mun. Eng., Vol. 37, page 387.

"A Simple Way of Making Waterproof Concrete." Eng. News, Vol. 58, page 339. (Editorial.)

"Waterproofing—An Engineering Problem." By Myron H. Lewis. Proc., Engineers' Club of Philadelphia, Vol. 25, page 389. (A general discussion, with a description of the design of waterproofing systems and the circumstances which must be taken into account in their use.)

"Paints for Concrete; Their Need and Requirements." By G. D. White. Proc., Am. Soc. for Testing Materials, Vol. 9, page 520. (Gives treatments preparatory to the use of linseed oil paint, and value of different paints.)

Abstract of same. "On Waterproofing Concrete." Scientific American, Vol. 101, page 243.

"Report of Committee S on Waterproofing Materials." Proc., Am. Soc. for Testing Materials, Vol. 9, page 292. (Discusses the use of sand, hydrated lime, colloidal clay, and bituminous materials.)

"Tank Construction for Excluding Water from a Basement." Eng. Record, Vol. 59, page 39. (Describes the scheme for waterproofing the sub-basement of the Keyser Building, in Baltimore, by placing Hydrex felt waterproofing on the floor and inside the walls and building against it a concrete tank reinforced against the external hydrostatic pressure.)

"Peintures Sous-Marines et Peintures Ignifuges." By Ch. Coffignier.

Revue de Metallurgie, Vol. 6, page 734. (Discusses waterproof and fireproof paints, and their elements.)

"Covered Reservoirs; Some Experiences in the Use of Concrete in Their Construction, and in Making Them Watertight." By Frank L. Fuller. Journal, New England Water-Works Association, Vol. 23, page 204. (Discusses the use of plaster coats of cement and sand, pitch or hydrated lime.)

"Methods of Testing Cements for Water-proofing Properties." By W. Purves Taylor. Proc., Am. Soc. for Testing Materials, Vol. 6, page 334. (Methods of testing the permeability of cement.)

"Waterproofing Concrete and Masonry." By Edward W. DeKnight. Eng. News, Vol. 57, page 187. (General principles to be applied in the use of waterproofing.)

"Tests on Permeability of Concrete." By F. M. McCullough. Proc., First Annual Meeting of the Engineering Society of Wisconsin, page 99. (Gives results of tests of fourteen ordinary waterproofing products found on the market, including felt, damp-proof, antihydrine, etc.)

Abstract of same. "Efficiency of Compounds for Waterproofing Concrete." Eng. Record, Vol. 61, page 79; Eng.-Contr., Vol. 33, page 3.

"Waterproofing Compounds" (letter). By J. F. Machod. Eng. Record, Vol. 61, page 200. (Tests with "Aquabar," a waterproofing compound.)

"Tests of Concrete for Permeability." Eng. Record, Vol. 61, page 695. (Tests made by the Louisville (Ky.) Commissioners of Sewerage upon concrete treated by various waterproofing compounds.)

"The New York Times Building." By Corydon Tyler Purdy. Proc., Institution of Civil Engineers, Vol. 178, page 188. (Waterproofing of underground stories consists of layers of felt and burlap laid in hot asphalt.)

"Elevating Tracks of the Philadelphia, Baltimore & Washington Railroad Through Wilmington, Del." By H. S. Righter. Proc., Engineers' Club of Philadelphia, Vol. 25, page 335. (Five layers of Hydrex felt were laid shingle fashion over the top of the backing and spandrel walls, and mopped with hot asphalt or Hydrex compound.)

"Concrete-Steel Construction," page 247. By Emil Mörsch. Ed. 3. New York, 1910. Eng. News. (Method of waterproofing cellars by constructing shallow reinforced concrete arches on which a water-tight cement finish is laid with a concrete filling over it.)

"Concise Treatise on Reinforced Concrete," page 13. By Charles F. Marsh. (Advocates a special layer of waterproofing for all important works, and mentions sheetings prepared with bitumen for this purpose.)

"Section 1 of the Washington Street Tunnel, Chicago." Eng. Record, Vol. 61, page 404. (The waterproofing of the outside consists of 8 in. of brick laid in hot asphalt and a 1-in. layer of asphalt on the exterior of that.)

"Waterproofing Reinforced Concrete Coal Bunkers." By A. T. Schreiber. Eng. Record, Vol. 59, page 238.

"Waterproofing a Shaft of the Blue Island Avenue Water Tunnel at

Chicago." Eng. News, Vol. 62, page 506. (The waterproofing consisted of a 6-in. lining of cement grout.)

"The Waltham Reservoir." By Bertram Brewer. Jour., N. E. W. W. Assoc., Vol. 21, page 330. (Contains specifications for waterproofing.)

"Waterproofing Concrete Roofs, San Francisco Harbor Fortification Work." By J. H. G. Wolf. Eng. News, Vol. 55, page 473. (Method of waterproofing concrete roof to a battery; mopped with a heavy coating of asphaltum and covered with roofing felt three-ply and four-ply.)

"Waterproofing the Substructure of the West Street Building, New York." Eng. Record, Vol. 53, page 601. (Asphaltic pitch and Siaster fabric are used for waterproofing.)

"The Design and Construction of a Concrete House." By John Wynkoop. Cement Age, Vol. 9, page 14. (Specifications for waterproofing with felt and for dampproofing with plant.)

"Waterproofing with Coal-Tar and Sand." Eng.-Contr., Vol. 27, page 149.

DISCUSSION.

(The report of the Committee on Masonry was presented by the Chairman, Mr. W. H. Petersen, Engineer Maintenance of Way, Chicago, Rock Island & Pacific Railway.)

Mr. W. H. Petersen:—On the revision of the Manual, we have made but few changes and the changes have made the wording more concise, in some cases, by the addition of a few words or sentences, where we thought it would be necessary to more clearly define the meaning, and in other cases the uniting of several paragraphs, so as to bring the subjects of the same nature together.

The President:—Unless there is objection, the four definitions as submitted by the Committee will be accepted. The changes are merely in the wording, and there is practically no change in the essential features.

Mr. C. E. Lindsay (New York Central & Hudson River):—At the top of page 175 of the Bulletin, under 4, we find the minimum diameter of the screen is given. Does the Committee care to establish a maximum in that connection?

The President:—We will take these up in order. There is no new matter in the specifications except No. 8 at the top of page 176. We will begin with the specifications for stone masonry, No. 3, and the Secretary will read caption by caption.

The Secretary:—"3. Stone shall be of the kinds designated and shall be hard and durable, of approved quality and shape, free from seams, or other imperfections. Unseasoned stone shall not be used where liable to injury by frost."

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I ask whether or not these specifications have not already been adopted by the Association.

The President:—These are changes made in the adopted specifications. The present form is to the left and the proposed form to the right.

Mr. Wendt:—My understanding is that in the case of most of them it is simply re-writing. In No. 3, I understand, there is no change.

The President:—There is no important change until you get to No. 8, which is new.

Mr. Wendt:—In the interest of progress, I ask that all be approved up to No. 8. They have been before us heretofore and have been in the Manual as recommended practice.

Mr. Richard L. Humphrey (Consulting Engineer):—The proposed revisions of the Manual are largely changes in phraseology in order to make the recommendations more concise. For example; in paragraph 3 of the Manual, in the specifications for stone masonry, appears the phrase "free from seams and other imperfections, of approved quality and shape." This is manifestly incorrect phraseology and it has, therefore, been transposed so as to place the phrase, "of approved quality and shape," in its proper relation to the rest of the sentence.

There have also been changes made in some of the paragraphs relating to the specifications for plain and reinforced concrete; this being for the purpose of simplifying and rendering the subject-matter clearer.

The only new matter is paragraph 8, and I therefore second Mr. Wendt's motion that the revisions be approved.

(The motion carried.)

Mr. W. F. Steffens (Boston & Albany) :—In reference to paragraph 9, on page 174, is it the intention that the mass is to be uniform in color after mixing? I think the usual practice in securing uniformity of color is to mix the sand and cement dry—that is, where the uniformity of color can be most thoroughly detected.

Mr. Petersen :—It refers to dry mixing of sand and cement and the addition of the water afterwards.

The President:—The Committee explains that that means mixing after the water is added to the mixture.

Mr. Steffens:—Is not that opposed to the usual practice? We try to get the uniform color as we mix the sand and cement dry. That is the average instruction of specifications.

Mr. Petersen :—As sand and cement are mixed dry until they are of a uniform color and the water is added, the resultant should be of uniform color also.

Mr. Steffens:—Uniformity of color is the criterion sought to be gained by dry mixing.

The Secretary:—"8. (New.) Shrinkage and temperature reinforcement: Reinforcement for shrinkage or temperature stresses, in amount generally not less than one-third of 1 per cent., and of a form which will develop a high bond resistance, should be placed and be well distributed near the exposed surface of the concrete.

"9. Old 8 renumbered.

"It is recommended that the provisions of the latest report of the Committee on Uniform Tests of Cement of the American Society of Civil Engineers be incorporated in the revised Manual."

Mr. Wendt:—I move the approval of both No. 8 and No. 9.

(The motion carried.)

The President:—We will pass to page 210 and take up the question of monolithic construction.

Mr. Petersen :—The Committee has worked on this subject for two years, and this is a continuation of our report and this gives what we have decided upon as a definition of a monolith of concrete, and also monolithic concrete construction.

The President:—These definitions were referred back to the Committee a year ago for revision. If there is no objection they will stand as submitted.

We will turn to page 213 and the conclusions of the Committee for publication in the Manual.

The Secretary:—"Conclusion (1) That monolithic concrete construction may be used without danger of cracking for abutments of any length that the working conditions will permit, provided the length does not exceed about three times the height.

"Conclusion (2) That where abutments with wing walls are not of monolithic construction, joints should be provided at the intersections of the wing walls and the body of the abutments.

"Conclusion (3) That reinforced concrete abutments may be built in units of any length that economic conditions will permit.

"Conclusion (4) That monolithic concrete construction may be used for arches where the conditions will permit, otherwise the arch ring should be constructed with radial joints."

Mr. Wendt:—I move the approval of these conclusions 1, 2, 3 and 4.

(The motion carried.)

Mr. Steffens:—At the bottom of page 213 in the matter headed, "Investigate and report on the use of reinforced concrete trestles, typical designs and cost," mention is particularly made of the flat slab trestle construction, which has been used so extensively by the roads centering in Chicago. There is another type of flat slab work, however, that has been used. There is no representative of the Southern Railway here, unfortunately. The Southern Railway has built in North Carolina a bridge of girder construction, with floor beams, stringers and slabs, of reinforced concrete. It might be well for the Committee to make note of the fact and see if plans can be obtained so that mention may be made in the Proceedings of this construction.

The President:—The Committee will take cognizance of that.

Mr. Steffens:—I have been very much interested, as undoubtedly the others have, in the use of compounds placed dry, or by solution, in mortars for waterproofing purposes. There is bare mention made of such in the report, but unfortunately there is nothing said of the chemical nature of such compounds, or their effects on the resulting mortars. It seems that the Committee might well give a brief analysis of such substances as pertinent to the nature of the report. The usual soap and alum method is spoken of; the other is merely touched on, but it might well be explained in detail.

Mr. Petersen:—We intend to continue that subject into the coming year, and will include it in next year's report. At the bottom of page 178 we have given certain observations which are gathered from the reports of the various railroads, which are indications of what we can expect from the various types of waterproofing, but there are no conclusions presented.

The President:—Are there any other portions of the Committee's report not discussed on which information is desired or discussion is thought necessary? Mr. Loweth, will you give some observations concerning concrete trestles on your road?

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul) :—I do not know that there is much to add to what the Committee has stated in its excellent report. The Chicago, Milwaukee & St. Paul Railway has for many years been rebuilding reinforced concrete culverts, generally with flat tops; frequently these had double openings, and carried the track directly without any embankment between, and were really concrete trestles. The extension of this form of construction to several spans and with higher openings naturally followed, and the concrete trestle was the result, and sometime since it became a standard type of structure on the Chicago, Milwaukee & St. Paul Railway. It has been used quite extensively and doubtlessly will continue to be.

We find the cost of concrete trestles, speaking generally, from $26 to $33 per linear foot, varying with the magnitude of the work and local conditions. They have a large field of usefulness in that they permit of permanent construction at much less expense in many cases than would be possible with steel-work of any kind.

We have many bridges consisting of steel spans over the main channel of the stream with pile and timber approaches, through which water flows only during floods. We have been replacing such pile approaches quite extensively with concrete trestles, and have also used them in place of pile bridges where the conditions of stream flow would permit. The usual span length is 15 ft. 6 in. and at times up to 18 ft. Sometimes the slabs are built under traffic, but there are a number of difficulties in doing this and usually they are built on false-work to one side of the permanent structure and, when seasoned, shifted laterally into place on the concrete piers; sometimes the slabs are built at some distance from the bridge and are transported and put into place by derrick cars.

There has been an increasing danger of bridge fires due to cinders dropping from the new form of locomotive ashpans, a requirement of a recent federal law; with concrete ballast trestles this danger is entirely removed. Of course the same result could be largely accomplished with a creosoted timber ballast floor trestle. While we have used a great deal of that type of structure, it is not as favorably considered on account of its less permanent qualities.

The President:—We would like Mr. Cartlidge's experience on the Burlington. Mr. Cartlidge is not present.

Mr. Loweth:—I think Mr. Baldwin of the Illinois Central has used this type of construction largely.

Mr. A. S. Baldwin (Illinois Central) :—We have not used concrete construction as yet in trestles. We have used the slab construction in culverts for some time, practically the same methods that have been used elsewhere. There is a suggestion I would like to make, arising from Mr. Loweth's remarks, with reference to the use of creosoted trestles; that is, in a comparison of the two methods of construction it is very important that the liability of the creosoted trestle taking fire should be considered. Our losses during the last year from fires in connection with creosoted trestles have been very heavy. We have had several thousand feet of these trestles burn.

The President:—Open deck or ballasted floor?

Mr. A. S. Baldwin:—Ballasted floor decks. In some cases we have not been able to trace the exact cause of those fires. Investigation goes to show that as a general rule when you capitalize the cost of a concrete structure, it does not, from the standpoint of ultimate cost, compare favorably with the creosoted structure. At the same time I believe if reliable statistics could be obtained as to the amount of loss in creosoted structures by fire, that the result would be different, and we are now endeavoring to get some actual data as to that, and if this Committee gets some information in that line, it may be valuable to the Association.

Mr. Loweth:—As a result of our experience with concrete trestles we shall doubtless make some small modifications in the design as illustrated in the Committee's report; generally they will be quite minor. Perhaps the most important will be the placing of a metal plate between the slabs and the tops of the piers, so as to permit of a freer expansion and contraction without the tendency of chipping off of the corners of both slabs and piers.

The President:—We would like to hear from the Missouri Pacific representative, Mr. C. E. Smith.

Mr. C. E. Smith (Missouri Pacific):—I have looked into the use of reinforced concrete trestles, and have not found where we would be justified in adopting that form of construction. Our trestles cost about $8 a running foot, maintenance about 75 cents per foot, fire losses about 5 cents per foot. The interest, at 5 per cent. on $8 per foot, is 40 cents, making a total of $1.20 per foot per year cost to the railroad company for the timber trestle. As against that, the reinforced concrete trestle at $30 per foot would have an interest charge of $1.50, to which would be added 20 cents per foot for track maintenance, which would be $1.70, or approximately a difference of 50 cents per foot increased cost to the railroad company for the concrete trestle. We have about 150 miles of timber trestles, or in round numbers 800,000 linear ft. Of that number, 300,000 ft. will ultimately be disposed of, either by filling or by replacement by steel structures. The other 500,000 ft. at 50 cents per foot, would increase the cost to the railroad company $250,000 per year, if reinforced concrete trestles were adopted. I would like to hear from some of the others as to whether we would be justified in increasing the cost to the company to that extent.

Mr. F. M. Patterson (Chicago, Burlington & Quincy):—It seems to me this is a question of trestles that could be probably replaced by filling, and they naturally would be; it is a question only of where trestles or bridges of some kind must be maintained.

The President:—We would like to hear from Mr. W. L. Seddon, of the Seaboard Air Line.

Mr. W. L. Seddon (Seaboard Air Line):—I would like to ask whether there has been any other experience of fire losses as suggested by Mr. Baldwin. We have not used creosoted trestles long enough to get any data on that, but I have not expected a very great amount of loss from creosoted trestles. From my observations of creosoted telephone poles that went through the conflagration at Jacksonville, Fla., they were the only things left in the way of wood that stood that conflagration, and I am interested in that particular point. I would like to know whether there has been any other experience along the line mentioned by Mr. Baldwin.

Mr. A. S. Baldwin:—With reference to the danger from fire to creosoted structures, I will state that our experience goes to show that there is less danger of a creosoted piece of timber catching fire than of a piece of old, defective timber. A spark on a piece of defective timber will start fire very readily, whereas if it comes against a sound piece of creosoted timber, it does not ignite and take fire readily; but after the fire starts in those structures it is so fierce as to become quickly uncontrollable. That is the case with creosoted ties that have been placed along the right-of-way. I do not think they catch quite as readily as other timber. They certainly do not catch as readily as old timbers, but after they start, one cannot do anything with them, the fire is so fierce and the heat is so intense it is impossible to control the fire. The fire is much more intense with creosoted timber.

Mr. Seddon:—Has your loss from fires been from fires originating on the right-of-way?

Mr. A. S. Baldwin:—In one case the loss was from an adjoining structure. In several other cases we have not been able to find out what was the cause of it. It seemed impossible to tell, but caused probably by fire dropping from the ashpan. The information that has come to us has gone to show that the right-of-way and the ground right immediately under the trestles had been very thoroughly scraped off, and that there was no undergrowth on it—no grass or weeds. We have not been able to determine the exact cause of some of those fires.

Mr. Seddon:—I examined the poles at Jacksonville after the conflagration there, and they seem to be charred about an eighth of an inch, and then the fire seemed to have choked itself.

The President:—I think there is a general theory that after the lighter oil evaporates from the surface the chance of creosoted material catching fire is remote.

Mr. Steffens:—In reading the report as to statistics of waterproofing metal structures, the item that impressed me most was the leaking of the waterproofing in contact with the web of the girder. There are a great number of cases noted. I believe that this trouble has been found to be universal. As far as a bridge is concerned, there is no difference in the principle of excluding water from that existing in a building—flashing. We have these excellent statistics as to failures of that sort. While probably this Committee could not consider that subject, could not the function of the Committee on Iron and Steel Structures be extended to include some typical, suggested designs of steel work to eliminate these weak points? I can suggest several solutions of the problem—and doubtless several of the members have also solved it—but would it not be well for the Association to include with the list of failures some of the successes, due to consideration of this important matter in connection with the design of the steel-work?

The President:—I would suggest that you reduce your remarks to writing and suggest to the Board of Direction that the matter be taken up.

Mr. C. E. Smith:—We have kept a good record of our fire losses for about two years and have found that about 95 per cent. of the fires start on top. A good many start from cinders that drop down between the end caps and back walls. A good many of them could be avoided by covering the deck with galvanized or other sheet iron. I understand some roads have used galvanized or other sheet iron on top of the stringers, and that it prevents the stringers catching fire. By placing galvanized iron on top of the ties, at the ends of the bridge, over the back walls, those fires would be eliminated. I would like to hear from some of the members who have used sheet or galvanized iron, either on top of the stringers or on top of the ties, as to whether they did or did not reduce the fire losses.

Mr. Loweth:—Last year the St. Paul Railway fireproofed the floors of about ten miles of timber bridges, and we shall probably do as much more this year. It is expensive, not only on account of the first cost of construction, but because it makes the inspection and future maintenance of the bridges more difficult. The floors of all timber bridges on the Coast extension of the St. Paul road (the Chicago, Milwaukee & Puget Sound Railway) are fireproofed from one end of the line to the other. So far we have not fireproofed timber floors on metal bridges.

This fireproofing has so far been of two kinds: in one, 1 in. wood strips are placed between the ties, nearly flush with the tops, and the deck then covered with ballast between the track rails, and also the spaces between track rails and outer guard timbers. The other method is to cover the tops of ties between and including the guard timbers with galvanized metal. We find it desirable to extend the fireproofing outside the track rails to and including the guard timbers. The gravel protection is much the cheaper. A pretty coarse gravel is required and where suitable gravel is not available, we use crushed stone. There is a tendency, especially on curves, for the gravel to shift over to one side, and in such cases strips nailed to the ties have remedied the trouble.

In comparing the cost of pile and timber bridges with more durable construction, it would appear necessary to include in the estimated cost of the first the cost of fireproofing. In connection with what Mr. Smith has said respecting the relative economy of various kinds of bridge construction; we are not always able to justify permanent bridge construction, or even the much cheaper creosoted timber ballasted floor trestles, on the score of economy alone; but the maintenance of timber structures is quite large and frequently underestimated, and surely something should be conceded for the greater safety of permanent construction.

Mr. C. E. Smith:—We have recently been offered by the Mechanical Department a lot of old scrap car roofing, which we figure can be applied to our trestles at a cost of 10 cents per running foot, which is practically no increase in cost. The stringers in our trestles last us eight to twelve years; in the South a relatively shorter period, perhaps eight years. On the other hand, the same timber when used in top boards and end posts of combination spans and protected by sheet iron frequently lasts twenty years or longer.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—Mr. Smith has asked for information in regard to galvanized iron. We have been using galvanized iron as protection for stringers and caps for ten years. We have had a great deal of difficulty in keeping galvanized iron on the stringers. It has a tendency to creep. The cause of creeping we have been unable to determine absolutely, but we have discovered measures that prevent it. Pine stringers, which have been well covered for ten years, are found in good condition, as good as they were when they were put in. Our fire losses last year on trestle work, out of a total of seven miles, amounted to 24 linear ft. Those trestles are all open deck. My attention was first called to the question of protecting stringers with galvanized iron by noticing the experience of the Cincinnati Southern Railroad. They had a lot of stringers that were put in in 1871. I had occasion to examine them after they were taken out, in 1889, and notwithstanding the fact that the galvanized iron had not been taken care of, had been permitted to creep and to be perforated, wherever the iron remained over the stringers, they showed almost no rot whatever. They were made out of white pine. It costs us 40 cents per foot of bridge to cover, in a very elaborate way, our stringers and caps. We take a gum cap or a red oak cap.

The President:—Is that 40 cents per linear foot of trestle?

Mr. McDonald:—Per linear foot of bridge. A red oak or gum cap can be made to last ten or fifteen years. Ordinary galvanized iron bought in the open market, when applied to trestle work, will last on some branch lines, five or six years, and on the main line, where sand is dropped from the locomotive, it lasts only about three years. Recent experiments have justified us in the adoption of a modern pure iron, and we think we are going to get at least an average of seven years' life out of that metal, and I expect to fully realize twenty years' life out of the timber by that method of protection.

The President:—Unless there is further discussion on this Committee's report, the Committee will be dismissed with the thanks of the Association.

REPORT OF COMMITTEE VI.—ON BUILDINGS.

(Bulletin 131.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Meetings of the Committee at the office of the Association and members present follow:

September 26, 1910: O. P. Chamberlain, Chairman; Maurice Coburn. Vice-Chairman; C. H. Fake, P. F. Gentine, C. W. Richey, H. Rettinghouse, E. N. Layfield.

November 28, 1910: Maurice Coburn, Vice-Chairman; C. H. Fake, E. N. Layfield, John S. Metcalf, H. Rettinghouse.

In accordance with the previous practice of this Committee, at a meeting held at the office of the Association, Chicago, September 26, 1910, the work for the season was divided among the Sub-Committees then appointed as follows:

Sub-Committee A—Roof Coverings:

Maurice Coburn, Chairman,
H. M. Cryder,
C. H. Fake,
P. F. Gentine,
H. Rettinghouse,
C. W. Richey.

Sub-Committee B—Tool Houses:

William T. Dorrance, Chairman,
George W. Andrews,
J. P. Canty,
D. R. Collin,
M. A. Long.

Sub-Committee C—Reinforced Concrete Coaling Stations:

E. N. Layfield, Chairman,
John S. Metcalf,
O. P. Chamberlain.

The topics submitted to your Committee follow, with the designation of the Sub-Committee to which each was referred:

(1) Consider revision of Manual; if no changes are recommended make statement accordingly. (Proceedings, Vol. 11, Part 2, p. 1022. Suggestions requested from all members of Committee VI.)

(2) Reinforced concrete coaling stations. (Proceedings, Vol. 10, Part 2, p. 1109, and Proceedings, Vol. 11, Part 2. p. 1027. Sub-Committee C.)

(3) Tool houses. (Vol. 11, Part 2, p. 1044. Sub-Committee B.)
(4) Roof coverings. (Vol. 11, Part 2, p. 1037. Sub-Committee A.)
(5) Make concise recommendations for next year's work. (Suggestions requested from all members of Committee VI.)

On the topics submitted by the Board of Direction your Committee begs leave to report as follows:

REVISION OF MANUAL.

(1) Consider revision of Manual; if no changes are recommended make statement accordingly.

As no recommendations were received from members of your Committee and a thorough revision of the Manual was made at the convention of 1910, your Committee recommends no further revision at the present time.

(2) REINFORCED CONCRETE COALING STATIONS.

(Sub-Committee C.)

A number of reinforced concrete coaling stations have been built since the report of last year, notably one by the Philadelphia & Reading Railway Company at Philadelphia, with a capacity for handling 700 tons of coal per day of 10 hours and with a storage capacity of 2,000 tons.

Your Committee has no further report to make at present, but desires to have the subject referred back to it for the purpose of noting and reporting on the operation of the stations already built and the progress in designing new ones.

(3) TOOL HOUSES.

(Sub-Committee B.)

The Committee reports progress on the subject of tool houses.

(4) ROOF COVERINGS.

(Sub-Committee A.)

The following report is to replace that of last year:

The Committee has deemed it best to first learn what it could concerning the bituminous roofing materials, that part of the subject about which the greatest amount of inaccurate information exists. We have discussed other types briefly and have also included a little information about methods of application, but the main portion of the report has been devoted to the built-up and prepared roofings of which the bituminous material is the essential constituent. We appreciate that the report is not at all evenly balanced, but if we had waited to prepare a satisfactory discussion it would be several years before any report could be made, and it was thought best to present what information we had, with the expectation of later on gradually strengthening the weak spots, and finally presenting complete specifications for the important materials, at the same time keeping pace with current progress.

THE BITUMINOUS ROOFING MATERIALS.

Information concerning the relative value of the bituminous materials for roofing is not easily available. The detailed knowledge held by the leading concerns preparing the materials has been acquired by expensive experience and is regarded as a valuable asset not to be shared by possible competitors and the ignorant purchaser. Those supposed to be expert in the matter, the manufacturers and the engineers, differ widely in their statements as to essential details.

The quality of the salesmanship is often below that of the roofing. The roofing advertisements are generally full of buncombe and the representative is sent out with a stock of talking points, many of which are misleading, to say the least. Those who have listened have been filled with confusion. We have endeavored to present some points which might help to clear up this confusion.

The bitumens are compounds of many different hydrocarbons with different chemical formulæ and widely-varying melting points. They are always accompanied by greater or less amounts of impurities, and are obtained either naturally or as the heavier distillates or residues of coal, petroleum or other organic substances. Their distinguishing characteristics are their elasticity and binding power or adhesiveness, their considerable immunity from action by water and their solubility in oils and certain other organic compounds. The bituminous substances vary so, and the knowledge concerning them is so limited and new that considerable confusion in regard to nomenclature and classification exists.

In the commercial preparation of the different bitumens obtained from coal and petroleum, distillation is used to mechanically divide them into classes of compounds having similar physical qualities. When in this process sufficient heat is applied to cause a chemical breaking down of some of the hydrocarbons, which ordinarily tends to separate them into their constituents, the operation is termed cracking.

Asphalt.—The term asphalt is ordinarily considered as referring to bitumens found naturally in the solid state and will be so used in this discussion. These are obtained all over the world with widely-varying qualities. Mention will be made of those most important commercially in this country.

The asphalts are generally stable in the atmosphere. As found naturally, they are not commercially available, even after the impurities are removed, being too hard and brittle for most purposes. This is ordinarily remedied by softening or fluxing with various oils, an operation requiring skill. The character of the fluxes has a most important effect upon the finished product. Petroleum products are ordinarily depended on for this purpose. The fluxes should be sufficiently stable to insure against too rapid hardening of the fluxed asphalt. They should be free from deleterious constituents and should be of such a character that they will combine with the asphalt to be fluxed so as to make a homogeneous and perfect solution. Certain fluxes which work well with certain asphalts are not at all suitable for use with other asphalts. Poor results are sometimes supposed to be due either to chemical action in the fluxes or to chemical action between the fluxes and the asphalts. Tars are sometimes employed for fluxing purposes, but they do not mix easily with the asphalt. As asphaltic compounds age they tend to become brittle and hard, losing their elasticity and binding power. Poor fluxing hastens this process.

Commercial refined asphalts intelligently and honestly refined should and do run very uniform. When they are compounded, however, brand names have very little significance, and less value, and should not be taken in themselves as indicative of the character or value of the compound. Some types of asphaltic compounds properly prepared and used have qualities which make them almost indispensable for some classes of roofing.

The asphalt which has been most widely exploited in the United States is that which comes from the Island of Trinidad. This occurs in a large deposit and has the valuable feature of being unusually uniform in quality. As mined it contains large percentages of water and of mineral matter in a finely divided state. There are also some soluble salts present in small quantity which possibly may help to explain the fact that it is acted upon by standing water, and is not suited for use in underground waterproofing and at points where it does not have a chance to dry out. This is not so serious a defect in a street pavement where the surface coating is made dense and where the pavement is covered by water for short periods only, although where depressions collect standing water deterioration soon results. Sunlight affects it somewhat but it is not volatile in the atmosphere. Perhaps thirty per cent. may be considered as a fair average of the amount of flux necessary to add to it for the preparation of an asphaltic roofing cement. To prepare it for use the water and what vegetable matter may be present are removed. Over a third of the refined product is mineral matter.

Bermudez asphalt comes from Venezuela, is not quite so uniform as the Trinidad and is softer than the other widely-known commercial solid asphalts. It contains but little mineral matter, but otherwise possesses many characteristics similar to those of the Trinidad.

In Colorado and Utah occur gilsonite and elaterite which have some characteristics in common and which are often nearly pure bitumen. Gilsonite is hard and brittle, requiring considerable quantities of flux to make it available for use. It is not always uniform in its qualities. It is to some extent exported and is used for varnish. It is claimed as the base of many of the asphalt roofings but is not a good saturant. Elaterite is more expensive, is softer than gilsonite and is not found in such large quantities. Some manufacturers of roofing claim to use it. We have not heard of its having any special superiority.

Grahamite or "Choctaw" which comes from Oklahoma is not much used for roofing. It does not dissolve readily in the ordinary fluxes and in its physical characteristics is more like soft coal.

Southern California has deposits of asphalt of excellent quality but their cost of mining and the excellent character of the California oil residuals has driven them out of use. When California asphalt is mentioned the oil residuals are ordinarily referred to.

Rock Asphalt or Mastic Rock.—Sandstone saturated with bitumen is found naturally in various places in the country, principally in California. It is sometimes known as mastic rock, and is more valuable for paving and floors than for roofing or waterproofing, where it is rarely used.

Maltha.—Maltha, in this country found mainly in California, is a semi-liquid asphalt containing light oils which tend to evaporate upon exposure to the atmosphere leaving what is practically an asphalt. It grades into the California petroleum and the deposits are not extensive enough to be of importance commercially. There are underground deposits of this material so heavy that they cannot be pumped and for which no practicable scheme of extraction has been devised.

Petroleum Residuals.—The petroleums found in the United States vary in quality according to their location. Hubbard* divides the important deposits into six fields, as follows:

Appalachian—From western New York through western Pennsylvania, eastern Ohio, northwestern West Virginia into eastern Kentucky and Tennessee.

Lima—Indiana—Northwestern Ohio and eastern Indiana.

Illinois—Southeastern Illinois.

Mid-Continent—Southeastern Kansas, eastern Oklahoma and northern Texas.

Gulf—Louisiana and all of Texas except the northern portion.

California—Southern California.

The Pennsylvania oils are rich in the paraffines and in the lighter and more valuable illuminating oils and naphthas. Most of the California oils are practically free from paraffines and have comparatively small quantities of the illuminating oils. They are darker in color, have a greater specific gravity and have what is known as an asphaltic base. The oils found in the intermediate fields have qualities varying between the two extremes in the order named.

Eastern oils are largely made up of compounds of the paraffine series. These vary in consistency from comparatively thin oil to hard scale paraffine. While most of the paraffine compounds are useless as binding materials, many of the fluid paraffines are excellent solvents for certain asphalts and are in every way suitable for use as a flux. In the early days of the asphalt industry almost all the pavements were laid with an asphalt cement in which the refined asphalt was fluxed with a residuum high in paraffine, and the fact that these pavements gave excellent

*Dust Preventives and Road Binders. Wiley & Sons, 1910.

results shows that reasonable quantities of even scale paraffine are not necessarily destructive to the value of asphalt cements. The state in which the paraffine exists in an asphalt cement, i. e., whether in complete solution or not, is of much more importance than the amount present so long as this is kept within reasonable limits.

The heavy residue from the distillation of the California oils is a substance with many of the desirable qualities of the best asphalts. The crude oil is distilled down to the required density and a product obtained with even and valuable qualities. Very large quantities of California oil asphalt have been used throughout the United States for paving and roofing purposes. Its use has not been at all confined to the Pacific Coast. It is probably true that more asphalt roofing felt has been saturated with California oil asphalt than with any other kind of asphalt. This oil asphalt when melted becomes very liquid at comparatively low temperatures, and, for this reason, is especially suitable for saturating felt.

The heavy residuals of the Gulf, Mid-Continent and Illinois petroleums are used in large quantities as substitutes for asphalts, frequently under that name. They are ordinarily less expensive than the natural asphalts. As compared with the California residuals, they contain more paraffine, are lower in ductility and adhesiveness and, except that some of the residuals of the Texas oils are very stable, are in most ways inferior for roofing. Sometimes they are used as adulterants with better materials. To make them more stable and less affected by heat and cold, air is blown through them while hot. This reduces their ductility and adhesiveness as well as their susceptibility to temperature changes. The blown oils are not as good saturants as an untreated residual, but for the protective coating of ready roofings they have considerable value as they are stable and are not readily affected by the heat of the sun. They are not selected for stone-surfaced roofings because of their lack of adhesiveness.

THE TARS.

Coal Tar.—From the distillation of bituminous coal, either in a plant for the production of illuminating gas or in a by-product coke oven the products may be roughly divided into four classes, the gas, the ammoniacal liquor which is the scrubbing water with the materials which it has absorbed from the distillates and which it holds in solution, the coal-tar, a heavy liquid containing the distillates insoluble in water which have settled away from the ammoniacal liquor and the coke.

The coal tar contains some water, various impurities and free carbon which after the water has been removed, is ordinarily from five to thirty-five per cent. of the total. This is carbon formed by the cracking of the hydrocarbons and is in a very finely divided condition. The percentage varies with the method of manufacture. The distillates or bitumen are composed of hydrocarbons which have widely-varying melting points and degrees of volatility. These may be roughly classified into light oils, creosotes and pitches. The character of the tar varies with the coal used and the manner in which the process is carried on. The tar from each plant has its individual characteristics. The greater the heat, the more the hydrocarbons are cracked into their constituents and the greater the amount of free carbon and of gas found and the less the amount of coal-tar. By carrying the process to its theoretical limit the final products of distillation would be gas and carbon.

The question of the relation between free carbon and coal tar is one of considerable importance. It is generally considered to be a valuable adjunct to roofing tars and pitches. Free carbon makes the material less affected by changes in temperature. Comparing two pitches of similar consistency at normal temperatures the one having the greater amount of free carbon must have to neutralize it a greater per cent. of the lighter, more elastic and to some extent more volatile hydrocarbons and less of the heavy pitches. When it is cold the pitch is less brittle and when it is hot it does not flow so readily because of the carbon present. Thus a tar of a given consistency may notwithstanding the fact that it contains large quantities of an inert material apparently have more life than another with less of the free carbon.

To determine the probable action of any tar or pitch under different temperatures its percentage of free carbon must be known as well as its melting point. The free carbon does not interfere with the saturating power in felt although it is liable to be largely deposited on the surface of the felt.

When coal-tar pitch is exposed to the weather there is found upon its surface a thin layer, hard and brittle, the residue after the drying out of the volatile oils. This acts as a sort of protective coating to what is underneath. As soon as it is disturbed, exposing fresh pitch, the process is repeated. High carbon tars seem to weather better than low carbon tars, the increased amounts of free carbon seeming to aid in the foundation of the skin or protective coating.

The amount of free carbon in the commercial product is often regulated by combining coke oven tar, which because of the design of the stills is low in free carbon, with gashouse tar. The coke oven processes where much attention is given to the by-products can be made very uniform. It cannot be said that gashouse coal-tar is better than by-product oven tar or vice versa.

The statement frequently made that tar roofing material suffers in quality because it has been robbed of constituents desired in the manufacture of chemicals is not true. The lighter constituents are distilled off to leave a pitch of a certain desired consistency. In this process air or steam is frequently blown into the still. This prevents the deposit of free carbon on the sides and bottom of the still and to some extent aids the escape of lighter oils which would otherwise be held in solution. These oils if present in the pitch would tend to gradually evaporate, making the pitch unstable. The other way to remove them is to use a heat where danger of damaging the tar exists.

Watergas Tar.—Watergas is made by passing steam over hot coke or anthracite coal, which, decomposing the steam, forms carbon monoxide and hydrogen. This does not possess sufficient illuminating power, and to enrich it, there is added a gas produced from petroleum which leaves a tar often used in place of coal-tar. In the process which it undergoes the oil residues are so changed by the high heat as to lose many of their characteristics and to acquire some of those of the compounds found in coal-tar. Compared with coal-tar, its oils have less antiseptic properties. As obtained from the gas manufacturers it is thinner, containing more water, more light oils and less of the pitches and no free carbon. It is distilled down and treated much as is coal-tar and its pitch is very similar in appearance to that of coal-tar.

Watergas tar decomposes easier than coal-tar. It often contains some paraffine though ordinarily not in sufficient quantities to affect the product. The crude watergas tar is also much more affected by water and is capable to a considerable extent of forming an emulsion with it. Good coal-tar is practically unaffected by water, and it deteriorates from the surface only. Oil tar products like the oil fluxes used with asphalts are liable to undergo chemical changes which may tend to make the entire mass hard and brittle.

Watergas is now made practically everywhere and ordinarily mixed with coal gas. In one large plant from the same amounts of gas the watergas produces about a third of the amount of tar that coal gas does. The coal gas considering its by-products is under favorable conditions the cheaper, but the watergas requires less of a plant and allows greater flexibility of operation. The prices of materials and the demand for coke affect the relative outputs. In the large plant previously spoken of the proportions of coal and watergas made vary between two and three of watergas to one of coal gas.

In the larger illuminating gas plants the two sorts of tar are generally separated, but in many of the smaller plants they are mixed together. There is no reason why they should not be kept separate except for the cost of separate receptacles. In this country, the by-product oven and gas-tars, both coal-tar and watergas tars, are bought by a comparatively limited number of concerns who closely guard their processes. They compound the different sorts possessing varying characteristics, endeavoring as far as possible with their supply and their desire for maximum profits to meet the needs and demands of the consumer. The consumer in his ignorance does not know what he is getting and probably usually does not know what he needs. The detection of oil-tar in coal-tar products is a difficult and uncertain matter, especially when it is under twenty-five per cent. of the total. We are not sure that it has been proven that a reasonable amount of watergas tar seriously injures a coal-tar for roofing purposes, especially when used as a saturant, although it is generally in disfavor.

Not long since practically the only use of tar was for roofing and the entire supply came from the manufacture of illuminating gas from coal. The situation has been changed by the increasing supply from by-product ovens, by the manufacture of watergas in large quantities, by the great demand for creosote oils and other by-products, by the use of coal-tar for waterproofing masonry, by its use for briquetting coal slack and by its adoption for use as a road binder as a protection against the ravages of the automobile.

We would sum up the remarks on the bituminous materials as follows:

With skill in compounding, based on a thorough working knowledge of the materials used, asphaltic compounds can be prepared of natural asphalts and oil residuals with valuable qualities for many different roofing needs, whose durability under known conditions can be foretold with considerable accuracy. The same can be said, perhaps with more certainty as to results, of the different tars. Either can suffer from adulteration and poor preparation. Considering first-class materials the coal-tar is cheaper, more easily affected by temperature changes, and is not acted upon by water nor is it liable to internal chemical changes.

From these compounds the only definite information that can be furnished by laboratory tests as to probable life and weathering properties is negative in its nature and quite inconclusive. Specifications to be enforced must include factory inspection and knowledge of materials used.

In preparing this information, we have had assistance from many sources. We are especially indebted to Messrs. Dow & Smith, Chemical Engineers, New York City. Dust Preventives and Road Binders by Prévost Hubbard (Wiley & Sons, 1910) gives a review of the different bitumens, with considerable information about them, which should be of value to all interested in the subject of roofing, though in some points his statements do not obtain general approval. The qualities essential to a good road binder are to a certain extent those valuable in a roofing material.

FELTS.

The felts used with almost all bituminous roofings play a very essential part in the final product.

The desirable qualities of the felt vary with the saturating material to be used. With asphalt, saturating power is the main desideratum. For coal-tar which under heat is much more liquid, this quality is not so necessary. All must be strong enough to avoid damage in handling before saturation. The strength of the finished product is due to a great extent to the saturation.

The felts are mainly made of rag stock which is chiefly cotton rags. Notwithstanding the statements of many manufacturers, all-wool felt is never used for roofing, because of its expense and because it would be too soft and tender to work. A certain proportion of wool rags helps to make a felt which is open and spongy with considerable saturating power. The best felts for saturation by asphalt rarely contain more than 25 or 35 per cent. of wool, and those for use with coal-tar contain much less. As ordinarily used the term wool-felt applies to a soft open felt with very little wool in it.

Sometimes paper stock, which is ordinarily wood pulp, though it may contain an appreciable percentage of straw, is used in small quantities if the felt is getting too soft. It has practically no saturating power but it can add to the cheapness of the material. If used in anything over two or three per cent. it is an adulterant to cheapen the product when it is made to sell to roofing manufacturers, or to make it less absorbent, as in the case of slaters' felt or hard felt for making up into two and three ply coal-tar felt.

The felt materials ordinarily come to the factory in large bales already sorted with fair accuracy and are bought according to different grades. These are used together in varying proportions to get different results and to meet variations in the materials. But little sorting is done at the plant except to watch for specially undesirable constituents.

The methods of manufacture have a considerable effect on the quality of the material. The felt must be well beaten to avoid large lumps, which are sources of weakness. The felt is made on a machine similar to that used for making ordinary paper and variations in its operation determine the quality of the finished products.

The dry felts are sold by weight. The standard is the amount which would lay 480 sq. ft. If a felt weighs 28 lbs. to 480 sq. ft., it is known as No. 28. For this reason felts sometimes have their weight increased by the addition of a mineral filler. This is nothing more than an adulterant which interferes with the saturating power. Some specifications which require a certain weight of felt get around such adulteration by requiring that the ash in the unsaturated felt must not exceed 5 per cent.

Felts of asbestos are used in one or two roofings. These are poor saturants and are more in the nature of protection to the asphalts. They will not burn or decay.

Jute woven in the form of burlap or canvas is used in some roofings to add strength. Its value is debatable. It is not a saturant like the felts and its fibers are not so thoroughly protected, making it liable on exposure to rot.

BUILT-UP ROOFS.

The main use of tar for roofing has been in the construction of built-up roofs where layers of felt saturated with tar are nailed down and by the use of a tar pitch protected and cemented together.

The following specification accompanied by the necessary diagrams give what is considered as good practice in the construction of a flat built-up roofing on wooden sheathing.

SPECIFICATION FOR FELT, PITCH AND GRAVEL OR SLAG ROOFING OVER BOARDS.

INCLINE.

This specification should not be used where roof incline exceeds three (3) in. to one foot. For steeper inclines modified specifications are required.

SPECIFICATION.

ROOFING.

First, lay one (1) thickness of sheathing paper, or unsaturated felt, weighing not less than five (5) lbs. per hundred (100) sq. ft., lapping the sheets at least one (1) in.

Second, lay two (2) plies of tarred felt, weighing fourteen (14) to sixteen (16) lbs. per hundred (100) sq. ft., lapping each sheet seventeen (17) in. over the preceding one, and nail as often as is necessary to hold in place until remaining felt is laid.

Third, coat the entire surface uniformly with straight run coal-tar pitch.

Fourth, lay three (3) plies of tarred felt. lapping each sheet twenty-two (22) in. over the preceding one, mopping with pitch the full twenty-two (22) in. on each sheet, so that in no place shall felt touch felt. Such nailing as is necessary shall be done so that all nails will be covered by not less than two (2) plies of felt.

Fifth, spread over the entire surface a uniform coating of pitch, into which, while hot, imbed not less than four hundred (400) lbs. of gravel, or three hundred (300) lbs. of slag, to each one hundred (100) sq. ft. The gravel, or slag, shall be from one-quarter (¼) to five-eighths (⅝) in. in size, dry, and free from dirt.

FLASHING.

Flashings shall be constructed as shown in detailed drawings.

LABELS.

All felt and pitch shall bear the manufacturer's label.

INSPECTION.

The roof may be inspected before the gravel or slag is applied by cutting a slit not less than three (3) ft. long at right angles to the way the felt is laid.

N. B.—To comply with the above specifications, the material necessary for each one hundred (100) sq. ft. of roof are approximately as follows: 100 sq. ft. sheathing paper, 80 to 90 lbs. tarred felt, 120 to 160 lbs. straight run coal-tar pitch, 400 lbs. gravel, or 300 lbs. slag.

In estimating felt, the average weight is practically fifteen (15) lbs., per one hundred (100) sq. ft., and about ten per cent. (10%) extra is required for laps.

In estimating pitch, the weather conditions and expertness of the workmen will affect the amount necessary for the moppings, and to properly bed gravel or slag.

The sheathing paper or unsaturated felt is placed on the bottom next to the roof boards, mainly to keep any pitch which might penetrate the two-ply felt above it from cementing the roofing to the sheathing. It also is of value in preventing the drying out of the roof through open joints from below. The saturated felts should be nailed where there is any chance of disturbance of the roof from underneath by wind and also enough to hold it in place while laying. The practice in regard to nailing varies in different parts of the country, but the fewer nails the better so long as the roof is held in place.

For a concrete roof the practice is similar except that a dry sheet is not necessary, there is no nailing and the concrete is first coated with pitch. Special care should be taken in regard to flashing and to prevent the roofing from being loosened at the edges either by wind or fire. Most leaks occur around flashings and openings.

The two layers of saturated felt first laid are necessary in order to carry and give full value to the amount of pitch which must be handled in one mopping. One of the troubles with built-up roofing as ordinarily laid is the difficulty in getting thorough moppings between the felt layers.

The felts are saturated with tar about as it comes from the gashouse with the water and other impurities removed. Oil-tar with its liquid qualities is said to be much used for this purpose. This is more permissible than it would be if the felt were to be exposed.

After the original two layers of saturated felt are used, the additional layers are merely to give additional thickness of wearing material, and with a roof properly laid, the greater the amount of felt and pitch used the greater the life of the roof. Ten-ply roofs have been laid. If too much pitch on top is used, it will run.

The pitch, much stiffer than tar, is made by distilling off the lighter oils and part of the creosote oils from the tar. The melting point of the pitch, a very important matter, depends upon the point to which the distillation is carried and the amount of free carbon. This should be varied somewhat to suit climatic conditions. Pitch for use in the fall in Winnipeg would be very difficult to work in New Orleans in the summer. The melting point of the pitch is not definite and in defining it a special specification is necessary. The use of a pitch with a melting point too high to allow satisfactory working and requiring the addition of fluxes on the work, giving a "cutback" pitch, is very liable to give uncertain results and should not be allowed. Worse than this is the use of tar or soft pitch stiffened by the use of land plaster, Portland cement or similar materials. This not only is uncertain in its results, but it gives a product liable to have short life. The best practice allows the use of nothing but straight run pitch.

The coating of gravel, crushed stone or slag helps to hold the pitch in place, protects it from wear and from the action of the elements and has considerable fire retardent value. If the material be too fine its holding power is lessened. If it be too large the stones are more apt to roll off and to damage the roof when it is walked upon and the pitch is not properly protected. Crushed material with its rough, sharp edges has a much better holding power than rounded gravel. It can be used to help get results on a steep roof. Sand or dirt with the gravel is objectionable, as it tends to prevent the gravel from bedding in the pitch and sometimes it mixes with the pitch, the resultant being more inert and liable to crack than the clean pitch.

In the final coating of a coal tar roof the effort is to get the maximum amount of pitch coating which can be kept in place. The flatter the roof the greater the amount of pitch that can be used and the better both pitch and gravel will stay where put. The best results are obtained when the slope of the roof is only enough to allow it to thoroughly drain. When it gets above two inches to the foot many object to its use, but the above specifications are considered by others as good practice up to three inches to the foot. Above that amount a built-up coal-tar roof, using these specifications, is of doubtful economy on permanent buildings, though fairly good results have been obtained from roofs steeper than this without special precautions. One method which gives good results is the addition of some asphalt to the pitch which is used for the top coating. This must be carefully done, as an intimate mixture of the asphalt and tar pitch is not easily obtained. The tar is often prepared for use on steep slopes by the addition of some finely-ground inert material which, as previously stated, is liable to give uncertain results. Actinolite is preferred for this purpose by some of the best roofers. Portland cement and land plaster are used but do not do as well, having chemical action on the other materials. Pitches prepared in this manner are perhaps to be preferred to stiff straight-run or asphalt pitches where skilled workmen are not available, as with the latter more skill is required in application. Slag is better than rounded gravel for steep roofs.

Where thorough inspection is not provided during construction the roof can be inspected by cutting a strip three feet long at right angles with the way the felt is laid before the gravel is applied. This can be readily repaired so that no damage is done to the roof.

When a built-up roof is in need of repair it can frequently be kept tight for a considerable time by patching and recoating, as may be necessary, with pitch and gravel. When the original roof was well laid it can be repaired by scraping off the coating of gravel and laying a new two or three ply roof on top.

Tile or brick can be substituted for the gravel or slag where the roof is liable to have much wear and when the structure warrants the expense. The tile are sometimes grouted in Portland cement, but a bituminous cement is usually considered better. Properly built this makes almost an ideal roof.

The built-up coal-tar roofs have shown by many years' trial their value for protecting flat roofs. Instances where a life of from twenty to thirty years has been obtained are not at all rare, but poor results due to poor workmanship and poor materials are not new. The claim that at the present time the ordinary purchaser cannot be sure of getting coal-tar of the quality of the best of that formerly produced would seem to have justification. At the same time, the oil-tar may be no worse than the fluxes and residuals frequently used with competing materials. Pure coal-tar and coal-tar pitch are still made, and the dealers in roofing materials can, if they desire, furnish materials as good as any which have been sold in the past. Such materials, of course, are not the cheapest and where competition is severe the quality is liable to suffer. About all that can now be done to get the desired results is to be willing to pay the price and trust to the dealers.

The chances for poor workmanship are many and the most thorough inspection is very desirable. The moppings between the felts can be slighted, the flashing and work around gutters and openings neglected, the materials may be adulterated on the work and the quantities of pitch and gravel cut down. The cost of materials and the cost of laying for any job can be estimated within close limits and no contracts should be let which will require a slighting of the work to avoid a loss.

As an indication of what can be done in territory adjacent to Chicago and St. Louis the following figures may be of interest. They show actual costs on a roof of about five hundred squares laid according to the specifications given above. The work was seventy-five miles from the gravel supply and one hundred and seventy-five miles from the headquarters of the contractor, who paid all freight and fare. This work was done close to a railroad track, so that nothing was necessary for hauling to the work. Nothing is included for overhead or fixed charges or for profit.

Cost per square:

5 lbs. sheathing paper	$ .12
155 lbs. pitch at 60c per cwt	.93
85 lbs. felt to square at $1.40 per cwt	1.19
Nails and caps	.05
Cleats for flashing	.05
Gravel (about one-seventh of a yard)	.23
Labor, including hauling, board and railroad fare	1.15
	$3.72

Where, for temporary buildings or other causes, a cheaper roof than the standard specifications call for is desired, a saving in the quantities of material can be made by reducing the number of plies. From this fair results can be obtained.

Plastic Roofing.—This is a sort of built-up roof used especially on steep slopes, where in place of using ordinary roofing pitch we have a compound of some fine inert substance with tar or some other bituminous material which is plastic when warm and which can be applied with a trowel. It is not extensively used and its application is mainly confined to the eastern part of the country. Except for steep slopes it has little value, as it lacks elasticity and because it requires considerable skill to get the proper proportions.

Built-up Asphalt Roofing.—Built-up asphalt roofs have been used with considerable success. Asphalt is much less affected by temperature changes. For a roofing cement it must have considerable proportions of flux to make it easy of application. Coal-tar felts are often used with asphalt roofing cements. With asphalt, the dry sheet can ordinarily be avoided. Where first-class material is used it is ordinarily expensive and it is harder to handle. Except for steeper slopes than are suitable for coal-tar, its use is not recommended unless unusual conditions make it more economical.

Asphalt coatings on a concrete deck are liable to lose their adhesion to the concrete, due possibly to destruction of the top surface of the concrete by acid in the asphalt flux. Asphalt used on a built-up roof is very liable to have a short life and the builder of built-up roofs avoids it ordinarily.

Built-up Asbestos Roofing.—There is on the market materials for a built-up asbestos and asphalt roof. The asbestos, besides its well-known fire-resisting value, has the advantage that, being mineral, it will not decay. It is not as absorbent as felt and acts more as a protection to the bitumens than as a saturant. This roofing is ordinarily applied only by the manufacturers. The fire-resisting value of the asbestos is perhaps overrated and the wearing qualities of the top layer are questioned.

This roofing should have its best value on comparatively steep roofs. We are unable to express any opinion as to its value but should judge that its expense is not justified for ordinary conditions.

PREPARED OR READY ROOFINGS.

To compete with it and to meet some of the conditions where a built-up roof is not satisfactory or too expensive, innumerable prepared or ready roofings have been put on the market. These ordinarily come in rolls accompanied by the nails and cement necessary to apply them. They vary from a very light felt with the cheapest possible saturant and enough sand or soapstone coating to prevent sticking in the rolls, to a sheet so heavy that it cannot be rolled, built up of heavy felts and strengthening materials and saturated and protected by carefully prepared compounds, possibly protected also by a coating of crushed stone. The durability and fire-resisting value vary to as great a degree. Ordinarily the ready roofings are cheaper than other types, but some brands sell at prices considerably above the cost of a good built-up roof. To a certain extent the weight is designated by the ply, but there is no uniformity of practice among the different manufacturers. A two-ply roofing may mean a heavier weight than a one-ply, or it may mean two separate felts stuck together.

The saturant should be liquid enough at workable temperatures to thoroughly impregnate the felt. The protective coating should be stable and not easily affected by the elements. The saturation of the felt is a very vital feature. This must retain its life and elasticity to keep the roofing efficient. A protective coating of material similar to the saturation is often used with the idea of helping to maintain the life of the saturating material. In any event, the coating must be elastic like the saturated felt.

With a coal-tar roofing made to be rolled, it is impossible to use nearly as much material as is found necessary for a good built-up roofing and such a roofing, even if made in the very best manner, cannot be expected to have a life comparable with that of a first-class built-up roof. Tar is not considered the best material for a high-grade ready roofing.

To successfully saturate with most asphalts a felt much more open than that necessary for coal-tar must be used. Asphalt must be heated to a much higher degree than ordinary coal-tar to successfully saturate, and care must be taken to avoid charring the felt in the operation. Trinidad is but rarely, if at all, used for this purpose, it containing too much mineral matter and requiring too great a heat. California oil residuals are especially suitable for saturation purposes. At a temperature of 300 degrees Fahrenheit they are almost as limpid as water and at this temperature there would be no danger of charring the felt. They come between the so-called natural asphalts and coal-tar in their saturating properties and their susceptibility to changes in temperament.

The objections to asphaltic compounds for built-up roofings do not all apply for ready roofings made in the factory. Since the amount of material used is less, its cost is not of such great importance. None of the asphalts have all the desired qualities and to produce certain results compounds of several different asphalts, residual pitches and fluxes are frequently used together. It is our understanding that Trinidad asphalt is seldom used as a protective coating, except in combination with other asphalts. Tar is sometimes used as a flux. Wax tailings, a residual obtained from petroleum in the manufacture of paraffine wax, and other similar substances are common ingredients. Resin, which gives better saturating power to many asphalts, making the solution more liquid, is also used. It must not form too large a proportion of the total, as it tends to make the final product brittle. Stearine pitch is used in the coating for some of the smooth-surfaced roofings. It is an animal by-product obtained from stearic acid used in the manufacture of candles. It is said to be very stable and to be practically unaffected by the action of the sun. Some say that the amount claimed to be used in roofings is considerably greater than the total product.

The cement for use in laying, which is furnished with the roofing, ordinarily contains some naphtha or something similar which serves as a drier.

Some ready roofings are adjusted by the manufacturer to suit the climate at the point of application. One concern selling all over the world keeps careful records of the temperature at its different markets and makes shipments accordingly.

The prepared roofings may be divided into two general classes—smooth and stone-surfaced. The stone-surfaced roofings are to a certain extent an adaptation of the built-up roofings. They frequently have at least two felts cemented together. The gravel or slag used must be uniform in size and finer than that available for a built-up roof. The steeper the roof the more chance they have to lose their stone coating. The amount of material that can be used in the heavier brands is limited to the amount that can be successfully rolled. If the stone be too large, the stone may damage the felt in rolling; if too small, the amount of pitch is limited.

The smooth-surfaced roofings are usually coated with some finely divided material to prevent sticking in the roll. Tar is not suitable for their protective coating, as it cannot easily be held in place in proper quantity without the stone coating. The protective coating must be stable and not easily affected by changes in temperature. Blown oils are frequently used for this purpose. The smooth-surfaced roofings, as a general proposition, have less insulating and fire-resisting value than the heavier stone surfaced materials. For the smooth surfaced roofings a regular painting or recoating is usually necessary in order to get the best life.

Tarred felts in which there are two or three plies of felts cemented together with pitch are sold all ready to be laid. They must be covered with a tar coating upon laying and at frequent intervals to show any value at all.

The asbestos roofings are made to include one or more plies of asbestos felt, with possibly a jute center. They are cemented together by asphaltic cements. In the heavier brands they are expensive. The asbestos felts are poor saturants. These roofings have given promise of good results and are widely used. The asbestos will not burn, but the amount used is so small that its insulating value is not great, and the value of these roofings from the standpoint of fire protection is probably frequently over-estimated.

Burlap or jute canvas is used in ready roofings as a strengthening material. It is not a good saturant and must be kept thoroughly coated, as otherwise it goes to pieces readily. It is employed in conjunction with either felts or asbestos sheets. We question its value, feeling that better results can be obtained from a proper quantity of ordinary felt.

The ready roofing is weak in that with the narrow lap and a large part of the roof covered with but one layer of material a single defect can cause a leak. The fact that on a flat roof water is liable to back up under the upper layer is a chance for trouble. Care should be taken that a nail is not driven into a crack in the roof sheathing, as the nail will work out, leaving a hole in the felt for entrance of water. The exposed nailing, where it is used, may rust out and can cause a tear or leak around the nail hole. This exposed nailing is avoided in various ways. Some of the manufacturers of stone-surfaced roofings finish the upper part of the sheet, which is to be covered by the next sheet, without any stone coating. The next layer is cemented on this strip. The only nailing necessary is thus done on the covered strip, where it is covered up by the sheet above.

The use of tin caps under the head of nails to secure prepared roofing should be avoided. When used, they must be kept constantly coated to prevent the rapid disintegration of the steel plates of which they are composed. If this occurs the nail head stands clear of the roofing, which is then an easy prey to wind storms.. Care should be taken in the flashing and around the edges of the roof to have it thoroughly fastened down. Nails of a No. 12 gage wire with a cap made of cold-rolled hoop steel welded on in the factory are used for this purpose. Some recommend nailing every two inches, but with large-headed nails every three inches is usually considered enough.

One of the chances for trouble with many of the ready roofings is their tendency to stretch and wrinkle and the difficulty in laying them absolutely tight and flat. As the roofing grows older and brittle the wrinkles become danger spots which are liable to crack if walked on. The roofing should be as thoroughly stretched as possible in laying. Knot holes should be covered before applying the roofing. In cold weather it is well to warm the rolls to avoid any chance of cracking.

To secure architectural effect on steep roofs a prepared roofing may be applied in various ways. For instance, by running the felt with the pitch of the roof, the joints and roofing nails can be covered with a molded batten of wood about ⅞ in. x 1½ in., the under side of which should be rabbeted out to a depth of an eighth of an inch to make room for the heads of the roofing nails. The recess or rabbet is filled with cement accompanying the roofing and then securely nailed. This not only protects the nail heads driven to secure the roofing itself but adds stiffness and further protection against high winds getting under the seams and blowing off the entire covering. Roofs so prepared have the appearance of a standing seam tin roof and the otherwise plainness of this roofing material is relieved. This adds to the cost by increasing the amount of waste as well as requiring the battens.

In order to avoid the single thickness and narrow lap the ready roofings can be used in various combinations. A two-ply tarred felt laid under a two-ply stone-surfaced roofing or two layers of smooth-surface roofing give what is practically a four-ply roof, not as good as a five-ply built-up roof in all details, but sometimes cheaper. A smooth-surface roofing is sometimes used under tile or slate and sometimes a prepared roofing is laid on top of old shingles.

The ready roofings usually commence to show deterioration after they have been kept in stock for three or four months. In purchasing care should be taken to avoid old material.

The ready roofings are of value for small and isolated buildings where the cost of laying a built-up roof would be excessive and for temporary structures where a roof of long life is not necessary. They can be laid without the expert help required for a built-up roof and most brands can be used on any slopes, although on flat slopes extra precautions must be taken to prevent leaking. They can be obtained at almost any desired price, but ordinarily cheaper than a good built-up coal-tar roof.

So many inferior roofings have been sold, so many have been poorly laid or used in the wrong places, so much has had to be learned by bitter experience and there is such a chance for fraud that the ready roofings are shunned altogether by many builders who want good results. But experience is being gained gradually, and they fill many needs so well that their use is bound to increase in their proper field.

Most of the ready roofings are sold under a five or ten years' guarantee, and many contracts for built-up roofs are similarly prepared. To depend upon these guarantees alone does not give satisfactory results even though the manufacturer be financially responsible. He can expect more immediate profit by preparing a roof which he is sure will last six or seven years and selling it under a ten years' guarantee than by preparing a roof which he is sure will last for ten years. At best the life will be uncertain and with good luck a roof built for six or seven years or even less might last twice as long. If it should need extensive repairs before the guarantee runs out there is considerable chance that the manufacturer will not be called on to make the repairs, and if he is, the loss is not great. Guarantees are liable to be so worded as to afford various loopholes for avoiding expense and they should, if relied on, be carefully scrutinized. A good roofing should last much longer than any possible guarantee can provide for. If the guarantee is made good, there still may be nothing left at its expiration.

New and untried brands are constantly being put on the market. In some of the older ones which have gained a reputation inferior products are substituted. Many of the best ready roofings are made of compounds whose composition is kept secret. The only way now of being fairly sure of good results is to use a brand which has been shown by long tests to meet the desired conditions and which is made by a concern with a reputation for fair dealing. The same course would seem to be desirable in the awarding of contracts for built-up roofs, though with them track can be kept of the weight of material used and the work on the roof can be inspected.

This is not a satisfactory condition, and as indicated in the earlier part of the report it is hoped that before many years specifications can be devised which, coupled with the necessary tests and with efficient factory inspection, such as that the Underwriters Laboratories is furnishing for some materials, which is explained below, will do away with the ignorance and fraud now enveloping the bituminous roofing industry. We should then be able to buy roofing with as much certainty of quality as we can now expect in ordering steel rail. To this end our Association, working in conjunction with other organizations, should do its part.

WOOD SHINGLES.

A wood shingle roof properly laid and of good material will last for many years. Good shingles can still be obtained from the Pacific Coast for a reasonable price, though not equal to the white pine formerly obtainable. The nails ordinarily corrode before good shingles have deteriorated noticeably, allowing the shingles to become loosened and displaced. If the shingles are dipped in linseed oil or creosote their life will be considerably increased. Painting after laying with a linseed oil paint induces decay and should be avoided. The main objection to shingles is their fire hazard. When the roof is old and a little out of shape, it is especially dangerous, providing a chance for the lodgment of sparks. It must have a pitch of not less than six inches to the foot.

To avoid the chance of one joint coming over another, they should always be laid with at least three laps. With a 16-inch shingle not more than 4¾ inches should be exposed. There should be two and only two nails in each shingle.

SLATE.

Slate comes with considerably varying qualities. It should be hard and tough and have a well-defined vein which must not be too coarse. If too soft it will absorb moisture. If too brittle, it cannot be cut and punched without splitting, and it will easily be damaged by walking on the roof. Crystals are sometimes found which disintegrate on exposure to the weather. Acid gases in the air and freezing of absorbed water tend to cause a disintegration of the slate. A clear metallic ring when struck is an indication of soundness. A cracked or soft slate gives a muffled sound.

The color varies widely, but does not necessarily indicate its lasting qualities. Good unfading black slate can be obtained. Some of the black slate fades rapidly on exposure to the atmosphere, assuming colors considerably varied. Various shades of green, red and gray slates may be purchased, some of which retain their uniformity of color very well.

Slate should not be laid on a roof having less than a one-quarter pitch, and a one-third pitch is better. When it is flatter than this it is liable to leak from capillary attraction. Finely powdered snow, driven under the slate by high winds and, later on, melting and freezing, is liable to cause damage to a slate roof. To be sure of the best results it should be laid on a good waterproof felt. In nailing slate each piece should be secured by two nails. Where exposed to gases the nails should be as far as possible non-corrosive, as they frequently determine the life of the roof.

In laying, care should be taken to avoid cracking the slate by driving nails carelessly or too tight.

TILE.

Clay roofing tile, unglazed without being hard burnt, is more or less porous and moisture is liable to cause damage in freezing weather. If glazed, the glaze, if improperly made, is liable to decompose on exposure to the elements. Properly made, good roofing tile cannot be excelled for durability. With tile, it is a little harder to get a tight roof than with slate. Interlocking shapes have been devised, giving very good results in this respect, although there is liable to be danger from driving rain or snow. Sometimes the tile is bedded in a plastic cement, but ordinarily, to be sure of the best results, it is laid on a good waterproof felt. When laid on a close wood sheathing it is held in place by battens nailed horizontally on top of the sheathing and is fastened down by wire. Copper wire, not less than No. 12 gage, should be used for this purpose. Steel wire or bands are liable to corrode. Sometimes the tile is laid directly on steel or wooden purlins, which must be spaced to suit the length of the tile. With this construction the waterproof felt is, of course, impossible. Hips, valleys and combs of tile roofs are formed of shapes designed for that purpose. Tile should not be used on a roof having a pitch of less than six inches to the foot.

Flat roofs on expensive buildings are sometimes covered with a rectangular tile from three-fourths to one and one-fourth inches in thickness, which is used as a protection to a built-up roofing, replacing the gravel. This method is especially preferable where the roof is liable to be walked on to any extent. Vitrified brick could be used instead of tile.

IRON OR STEEL ROOFINGS.

The further the material varies from pure iron the more liable it is to corrosion, and a great deal of the trouble in such roofing is due to the poor steel used, which will not last more than a few years, no matter how protected.

During the past few years a very pure iron, made by new processes, has been put on the market. Laboratory tests would indicate that excellent results may be expected from this material. It is cheaper than charcoal iron, but more expensive than steel. We believe that its extensive use is justified but that it has not yet been tried in actual service long enough to warrant any positive recommendations.

Corrugated Iron or Steel.—Owing to the difficulty in getting good iron for this purpose this roofing is ordinarily avoided for railroad work. Galvanized, it does not give good results. If pure iron can be obtained, this material may be valuable for use in roofing certain buildings, such as some types of shop buildings and open umbrella shelter sheds.

Asbestos protected metal, lately introduced, is corrugated steel which is used with a bituminous coating covered with asbestos as a protection to the steel plate. This has not been in use long enough for any definite opinion to be given in regard to it.

Metal Shingles.—Metal shingles are used to some extent by different railroads. Of good material and properly protected, they have their uses.

Tin Plate.—Tin plate has a body of iron or steel. The coating is in most cases an alloy of lead and tin, with lead usually predominating. When tin is specified, the coating should consist of not less than 30 per cent. pure tin, nor more than 70 per cent. pure lead. Not less than 20 pounds of the coating should be used per box of 112 sheets 14 inches by 20 inches.

Where the coating is all of lead, it is called terne plate, and is used when cheapness is an object.

Good tin plate for roofing can still be had, and where it is desired to use this material for roof covering, one of the reliable brands of hand-dipped plate, not less than IX or No. 28 gage, should be selected. Rolled tin plate should not be used for roofing, guttering or valleys.

One method employed in the preparation of steel for roofing purposes is to pickle the steel in acid baths to cleanse the sheets of scale and dirt. Unless this process is most carefully followed by thorough cleansing, minute particles of acid remain to form within the plate itself an agent for its final destruction.

A great deal of very poor coating has been put on the market by the manufacturers of tin roofing material.

Tin roofing must be painted, and with a good paint, to preserve it. Tin roofings can be shown which have lasted twenty or thirty years on railroad structures, but the danger of securing poor material and the cost of maintenance have made conservative builders very cautious in its use. It has the great advantage of being available for all slopes and it is adaptable to special and difficult conditions.

Plates for tin roofing should be prepared in the shop, and one side for use next to the sheathing given a coat of good paint. In soldering these sheets rosin and not acid should be used, as the latter may find an opening in the tin coat and attack and destroy the body.

Where tin plate is used for roofing it should be with flat seam secret nailing for flat or less than eighth pitch roofs. For those of greater pitch than this a standing seam secret nailing may be used, care being taken that the seam is not carried into the gutter, where it would interfere with drainage and also be a possible cause of leaks through water making its way into the seams. The tin strips for this should be painted before application.

MISCELLANEOUS METALS.

Sheet Lead.—Sheet lead has been used abroad considerably. Its main value is due to its immunity from action by acid gases, but it is expensive. It has a tendency to cold flow from its own weight and it expands rapidly under heat.

Copper.—Good copper is not easily corroded, but it has a high rate of expansion and is expensive. It is not always possible to secure it of good quality, and impure it corrodes much more rapidly than it should. It is only desirable for railroad buildings in rare cases.

Copper and Nickel Alloy.—For expensive building an alloy of copper and nickel is sometimes used which is said to be practically non-corrosive. It works much like sheet copper, but is harder.

CONCRETE ROOFINGS.

Reinforced concrete tile, several square feet in area, have been used to a considerable extent on large sheds and factory buildings where the slight leakage from their somewhat open joints is not objectionable. They are usually placed directly on the purlins and kept in place by wire to the framework. They must be carefully made from good materials and made as dense as possible. Improved methods of forming under pressure may improve their quality. Their use as yet is largely experimental.

Small cement tile are in use to a limited extent and the criticism given concerning the reinforced tile also applies to them. They are less expensive than clay tile but are more absorbent and brittle. Improved methods of manufacture and further tests may later develop their merits for some purposes, but no economy has so far been shown by their use.

Asbestos shingles and corrugated sheets made of Portland cement and asbestos under pressure give promise of good results. They can be made in different colors and have some desirable advantages. They have not been in use long enough to prove their merit.

METHODS OF APPLICATION.

SHEATHING.—Wooden sheathing improperly laid has caused the value of many good roofings to be underestimated. Green lumber should never be used for this purpose, as it will shrink in drying, with a resultant distortion of the covering material. With a prepared roofing the felt will be given a wavelike appearance and the seams or joints forced open. With a slate roof the slate will be liable to be broken or loosened. Tin or copper coverings may be subjected to open seams and on a tile roof the shoulders in an interlocking type will be broken off. Sheathing boards should be surfaced to a uniform thickness, and ordinarily a plain board will be satisfactory. The sheathing should be thick enough to prevent the roofing nail from going through it. On some types of buildings the building should be stiffened by running the sheathing diagonally to the rafters and purlins. The nailing should be reduced to a minimum.

GUTTERS.—The use of gutters on railroad shops and on buildings close to the track should be discontinued where it can be done without causing inconvenience. The cost of cleaning and maintenance are considerable because the sparks and shop dust that accumulate at such points contain injurious acids. The roof drainage can frequently be taken care of by a cement gutter on the ground to carry it to sewers or drains.

For railroad purposes copper gutters are ordinarily the most economical when metal is used. Hand-dipped tin plate of the quality prescribed for roofing is better than galvanized iron.

For buildings covered with a prepared or built-up roofing the gutters can, if prepared with the proper care, give good results if formed in the roof and of the same material as the roofing.

Hanging gutters are frequently made of considerable length and must be strongly built, as otherwise they are liable to deflect from a uniform grade. They should be placed below the plane of the roof to avoid damage by sliding snow.

FLASHING.—Saturated felt, properly coated with good asphalt or pitch preparations, will ordinarily give better results than metallic flashings for buildings subjected to gases and fumes. The metallic flashings are ordinarily suitable on a building not exposed to gases. The importance of the thorough construction of flashings and work around openings cannot be overestimated and the subject deserves a thorough discussion.

FIRE PROTECTION.

What should be one of the most important considerations in the selection of roofing is its fire-resisting qualities, especially if the building be where it can be exposed to fire from adjacent structures. A roofing should, as far as possible, protect the structure from danger due to surrounding fires.

In congested districts a flat roof will have better fire-resisting value than a steeper one, as it is not so easily attacked by the flames and radiant heat, though it would afford a better resting place for flying brands. In large fires trouble frequently results with some types from the roofing being loosened about the edges, allowing it to curl up and the flames to get at the material underneath. Care should be taken to prevent this.

Roofing is being thoroughly studied by the Underwriters Laboratories in Chicago, an organization under the direction of the National Board of Fire Underwriters for the study of devices and materials having a bearing upon the protection of life and property from fire.

Their work is fully explained in two articles attached as appendices to this report. For some other articles which are related to fire prevention, they have, besides making laboratory tests, established classifications and specifications. They provide factory inspection all over this country when the manufacturer desires it. The purchaser who understands their work and classifications and wants good results is sure that the article is as represented, and when specifying an article which they have studied, wants nothing which does not bear their label. The interest of the Underwriters and the purchaser being identical, their results should be to the highest degree dependable and of great value.

The roofing tests are explained in the article by Mr. George W. Riddle. They hope later to furnish inspection in the factory, and where desired on the construction work for roofings of all kinds. It seems to the Committee that their work promises great value and that they should have our hearty co-operation in its prosecution.

The National Fire Protection Association has also devoted considerable attention to the question of roofings. In their report for 1907 can be found a report with specifications for the important materials.

CONCLUSIONS.

The following conclusions are incomplete and we appreciate that there are on the market other types and specially prepared articles which we have not included which have merit and which have or will show their value for use on railroad buildings. We expect later on to make additional conclusions concerning the materials omitted from these conclusions:

The annoyance and indirect expense occasioned by leaky and short-lived roofs are rarely compensated for by any possible saving in first cost.

In selecting a roofing there should be considered:

(1) Chance of leaks due to character of construction.

(2) Probable life, including chance of damage by the elements and by wear from other causes.

(3) Fire-resisting value.

(4) Cost of maintenance.

(5) Cost of materials.

(6) Cost of laying.

The ordinary practice of depending merely upon guarantees in selecting roofings cannot be trusted to secure proper results.

Where proper materials and the requisite skill in application are available, built-up roofs of coal-tar felt, coal-tar pitch and gravel or slag are recommended for roofs with a pitch of two inches or less to the foot.

Where the roof is to be subjected to wear and where the character of the construction warrants the expense, flat tiles or brick should be used as a protective coating to the roofing instead of gravel or slag.

As a general proposition railroad buildings should be designed to accommodate this type to allow it to be used, and because of economy in construction and of decreased fire hazard. A pitch of from one-half to one inch to the foot is better than anything steeper. Nothing but straight-run pitch should be used.

No contracts should be made for a built-up roof without a complete and positive specification including flashings, and the contract prices should not be less than those of the materials specified, plus a reasonable amount to cover the cost of laying and profit. Thorough inspection of workmanship and material is recommended.

For slopes of from two to six inches to the foot fair results can be expected if the top coating of pitch be especially prepared. This can be successfully done only by skilled workmen, who are also necessary for its application. Especial care must also be taken in the selection and application of the stone or slag coating.

Asphaltic compounds have value for a built-up roof for the top coating on slopes of from two to six inches to the foot. They may also be desirable at points where good coal-tar cannot be obtained, except at a cost appreciably greater. They should not be used except where they can be obtained from reputable dealers with complete information as to their constituents and where they can be applied by men skilled in their use.

Ready or prepared roofings are recommended for use on small, temporary and other buildings, where the cost, considering maintenance, of more expensive buildings, is not justified. They are of value for steep slopes where a built-up coal-tar roof cannot be used, and for locations where the skilled labor necessary for a built-up roof is not available. The steeper the slope the greater their relative value and the wider their economical field. The heavier varieties are, in general, the more desirable because of their chance for longer life and their greater fire-resisting value.

In making selections the reliability of the manufacturer, service tests and the cost should be governing factors.

In the laying of built-up and prepared roofings thoroughness in the preparation of flashings and work around openings is of vital importance.

Slate and tile of suitable quality, properly protected and fastened, can be recommended on roofs with a pitch of six inches to the foot or over, where expense is not the governing feature, and where they aid in producing the desired architectural effect, except that where there is much chance of driving snow, eight inches to the foot should be the flattest slope allowed.

Wood shingles, except in isolated locations where there is small danger from sparks, should not be used.

Steel or impure iron materials should be avoided, no matter how protected.

Respectfully submitted,

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Committee.

Appendix A.

THE OBJECTS OF TESTS AND INVESTIGATIONS AT UNDERWRITERS' LABORATORIES.*

By William H. Merrill.

Underwriters' Laboratories, Incorporated, as many of you know, is an institution operating under the direction of the National Board of Fire Underwriters. Its principal offices and testing station are located in Chicago. It has branch offices for the conduct of its business in thirty-two other cities in the United States and Canada. The Chicago plant occupies a three-story and basement building of fireproof construction containing something over 20,000 sq. ft. of floor space with a frontage of 116 ft. Yard space is provided for huts and large testing furnaces. The main building in Chicago is, perhaps, the best example in America of absolutely fireproof construction furnished with fireproof finish and equipment. It has been designed as a model to show a practical solution of many of the problems raised by the enormous and disproportionate loss by fire in the United States. Brick, terra cotta, concrete, stone, steel and iron are exclusively used in the structural features. The window frames and sash are of metal with wired glass, the doors are of metal, the desks and filing cases in the main office are of steel, and even some of the picture frames are of the same material. No wood or other combustible material is used in any portion of the finish or equipment. In addition the plant is equipped with automatic sprinklers, and the lighting and heating hazards are safeguarded with every known precaution applicable to their installation in buildings of frame construction. From this description you will realize that in this case the Underwriters have gone to the extreme in adopting in their own property all of the measures they are known to recommend in the property of others. Forty-five persons are employed in the Chicago plant, which has a value of approximately $100,000. The business of this institution is the examination and testing of appliances, devices, systems and materials having a bearing on the fire hazard. These include appliances designed to aid in extinguishing fires, such as automatic sprinklers, pumps, hand fire appliances, hose, hydrants, nozzles, valves, etc.; materials and devices designed to retard the spread of fire, such as structural methods and materials, fire doors and shutters, fire windows, etc., and machines and fittings which may be instrumental in causing a fire, such as gas and oil appliances, electrical fittings, chemicals and the various machines and appurtenances used in lighting and heating.

*An address delivered at the annual convention of the International Association of Fire Engineers, Syracuse, N. Y., August, 1910.

Up to the present time the Laboratories have examined and issued reports on over 5,000 different subjects or appliances, each report representing from one to a dozen series of investigations and experiments.

Summaries of the Laboratories' reports are promulgated on printed cards filed according to classifications, and cabinets containing these cards are maintained at the offices of the principal Boards of Underwriters and inspection bureaus in the United States, at many of the general offices of insurance companies, by some insurance firms, certain municipal departments, and at the local offices of the Laboratories in large cities. Much of the information is also freely distributed by means of lists of approved and permitted devices promulgated by the National Board of Fire Underwriters, and the results of the work in many classes of appliances are furnished directly to building owners, architects, users and all other persons interested by means of the Laboratories' labeling system, under which goods are inspected at factories by Laboratories' engineers and stamps, or labels, attached to such portion of the output as is found constructed in accordance with standard requirements.

By means of this service the quality of goods, in factories where approved articles are made, is carefully observed, and the use of labels restricted to such portion of the output as meets in all essentials the standard of efficiency shown by the sample originally tested and on which approval was based.

Experience has shown that this method is in every way superior for the purpose of bringing to the consumer the article he desires, for the purpose of placing competition between manufacturers beyond the point where deterioration in the quality of the output is made necessary, and for the proper protection of the Laboratories and the organization co-operating with them which are giving substantial recognition to efficient fire protection appliances.

It is also shown that an inspection and checking system of this nature can be efficiently operated under the Laboratories' direction without calling upon the manufacturer to give undue publicity to his manufacturing process, or subjecting him to any embarrassment or annoyance.

This service, which carrier the statement of the Laboratories as a manifest on the goods themselves, and which is safeguarded by competent inspectors at the factories where the goods are turned out by special agents going from one inspection office to another; by reports carefully scanned by examiners and engineers at the head office; by frequent examinations by Underwriters' inspectors in the localities where they are installed, and by rival manufacturers noting closely the quality of their competitors' wares when labeled, is proving itself the best solution yet devised of the many perplexing problems incident to bringing to the consumer the opinion of someone in authority on the merits of devices and materials in respect to the fire hazard.

The consumers' interest in obtaining these expressions through this channel is becoming more and more apparent. No such remarkable growth as the record shows in this branch of the work could have been possible without popular approval. For the year ending March 31 a total of sixteen million eight hundred and fifteen thousand nine hundred and twenty (16,815,920) labels were supplied inspectors—a noteworthy number when it is considered that the service has been in operation less than five years.

The object of examinations and tests at Underwriters' Laboratories is therefore to bring to the user the one best obtainable opinion on the merits or demerits of an appliance in respect to the fire hazard. That we have accomplished this object in a large measure is obvious to each one of you who have had occasion during recent years to look into the equipments of automatic sprinklers, fire doors and shutters, wired glass windows and their frames, fire door and fire window hardware, hand extinguishers, electrical, gasoline and acetylene machines and similar fittings and materials going into buildings, and private fire department apparatus for interior and exterior use. Now that we are beginning to take up public department apparatus, you will perhaps hear more of us. In every city in the world the interest of the chiefs in the character, the efficiency and the equipment of their fire departments is, I take it, in common with the interest of the insurance companies in these very things. The fact that you have devoted space on your program for discussion by two of your members of the benefits to the fire service from the inspections by engineers of the National Board of Fire Underwriters indicates that the natural auxiliary of such inspection service, competent and thorough tests at the National Board Laboratories, may also meet with your approval.

The Underwriters' Laboratories may be said to be engaged in a somewhat uncommon business. We are endeavoring to tell other people things that are necessary and beneficial for them to know in connection with their business where it comes into contact with our business. There have been a great many institutions and organizations and societies which have endeavored to do this in one field or another, and they have been successful or otherwise exactly in proportion to the real value to others of the advice they have assumed to give. An opinion on any proposition is of no lasting value or importance unless it is correct. It makes no difference how many authorities subscribe to a statement, or how many powers try to enforce a ruling based thereon. If it is fundamentally wrong, it cannot eventually prevail in America. This is peculiarly true in the case of the business in which we are engaged, and if I were asked to define the single principle which has been chiefly responsible for our measure of success to date, I should paraphrase Davy Crockett's remark and state: "Be sure you are right *before* you go ahead." There can be but one best opinion in respect to the merits or demerits of any device or material, system or appliance in its relation to the fire hazard. Manufacturers and buyers and users and engineers and experimenters and observers all form opinions, and many of these are often, of course, widely at variance, but among them all there is to be found somewhere a consensus which is correct. And just as we are able to work this out and promulgate it, we are able to serve to the best advantage our clients, the insurance companies and their customers—the assured. Our institution has been organized and developed along these lines. The error of supposing that any one man or any one set of men can be omnipotent in any particular field has never threatened us. Since the inception of the work we have safeguarded our institution against the possibility of hasty, unwise or arbitrary misuse of the authority delegated to us by withholding each conclusion arrived at as the result of Laboratory experimentation until it has received the careful scrutiny and the approval of all the principal men in this country best fitted through field experience and years of training to pass judgment thereon.

It is such an institution as one would presume Underwriters would fashion to help conserve their vast direct financial interest in the preservation of life and property against loss by fire.

Hundreds of millions of dollars are invested in the stock fire insurance companies doing business in the United States. The liabilities assumed by them under insurance contracts is equivalent to a large percentage of the aggregate property values of the country. This important direct financial interest in the efficiency of the Laboratories' work is an ever-present safeguard of its thoroughness and of its integrity.

If any further assurances are necessary as to the propriety of each one of you basing action on reports which reach you from Underwriters' Laboratories, I shall be happy to furnish them. In closing, I desire to express the hope that at no distant day you may hold your annual meeting in Chicago, so that each one of you may have an opportunity to visit the Laboratories and familiarize yourself with the work we are doing. I assure you we should be delighted to welcome you.

Appendix B.

TESTS ON ROOF COVERINGS.

PREPARATION OF STANDARD TEST METHODS FOR CLASSIFYING ROOF COVERINGS ACCORDING TO THEIR FIRE-RESISTING PROPERTIES.

By GEO. W. RIDDLE, Assistant Engineer, Underwriters' Laboratories, Inc.

Supplemental to the work of the Committee on Roofs and Roofings of the National Fire Protection Association which established specifications for the construction of several types of roof coverings, the Underwriters' Laboratories have during the past year designed and conducted a series of tests with a view of establishing standard test specifications by which all roof coverings may be classified according to their relative fire-resisting properties.

Although, as above stated, the object of these investigations is to establish a means of classifying roof coverings according to their fire-resisting properties, it has been borne in mind that the primary object of all roof coverings is to protect buildings and contents from the weather, and therefore an endeavor has been made to avoid requirements that would conflict with this primary function.

In the investigations made it has been the aim to establish a standard that would be sufficiently broad to permit the classification of roof coverings independent of the character of the roof structure upon which they might be applied. With this in view the tests have been designed to clearly show not only the relative flammability of roof coverings, but also their relative fire retardent properties, including the ability to resist the spread of fire on the surface of the coverings, protection afforded the roof structures against exposure to high temperatures, blanketing effect upon fires within the building, and also the flying brand hazard of the coverings. The effect of air currents of various velocities upon the coverings while under test was observed.

In adopting the test methods three separate fire tests were decided upon, each of which would approximate as closely as possible actual fire conditions and at the same time be capable of being reproduced for all classes of roofing coverings.

From the results obtained under the present method for testing combustible roof coverings, radiation and hot or burning brand tests of a modified form were decided upon, and in addition to these a flame exposure test was adopted. The methods of conducting both the radiation and hot brand tests and character of the furnaces used were entirely changed from methods formerly employed, so as to assure uniform conditions and at the same time permit of the testing of the roof coverings at the angle of inclination advocated for any particular type of coverings.

The radiation test decided upon consists of exposing the sample of the roof covering to be tested to the heat radiated from a steel plate heated to a prescribed temperature, and having exposed circular area 36 in. in diameter, the sample being placed parallel to and at a prescribed distance from the surface of the radiation plate. For the purpose a cylindrical furnace was designed having a conical top and provided with a steel radiation plate at the bottom 42 in. in diameter. The furnace is composed of a steel shell lined with fire brick on top and sides, which forms the combustion chamber, and is carried on trunnions suspended from an overhead track. The radiation plate is attached to the bottom of the furnace by means of a circular frame which fits around the plate and is bolted to the sides of the furnace. The frame covers the edges of the plate 4 in. at all points and provides a net exposure 36 in. in diameter.

Fig. 1. Furnace for Testing Roof Coverings.

View showing radiation furnace in position for testing sample deck.

The joints between the frame and plate are made tight with fire clay. The plate is heated by twelve gas blast burners inserted through the sides of the furnace and so set that the gases of combustion impinge on the conical top of the furnace and are given a whirling motion. The temperature of the plate is measured on the radiating surface at the center by means of a thermo-couple rigidly attached to the plate by a small pointed clip which presses the point of the couple against the plate. The furnace permits of easy control and the temperature of the plate is even throughout and can be maintained uniform for any length of time with but slight variation. The furnace is shown in Fig. 1.

In conducting the test the furnace is inclined at the desired angle and the plate heated to the proper temperature. As soon as the temperature has become constant, the sample is placed before the plate at the prescribed distance from it and at the same angle as the plate, the position of the sample being such that the lower edge of the plate is 12 in. from lower edge of the sample. During the test the surface of the sample is exposed to air currents of known velocities. The sample is thus exposed until failure.

The burning brand test consists of applying to the standard sample a burning brand composed of maple strips, 3 ft. long, set side by side about one inch apart, forming a grid 3 ft. sq. The pieces are held rigidly together with cleats on the upper side. The brand is ignited by placing it over a gas burner consisting of rows of small jets, which play on all parts. The brand is permitted to burn until the wooden strips are thoroughly ignited and covered with incandescent coals and then placed upon the sample.

In conducting this test the sample is set at the angle of inclination adopted for the particular covering and subjected to the desired air currents. The burning brand is then placed upon the covering so that its lower edge is 12 in. from the lower edge of the sample, and permitted to remain until entirely consumed. (See Fig. 2.)

Fig. 2. Test of Roof Covering.
Sample deck in position for Burning Brand Test, showing brand in place.

The flame exposure test consists of exposing the sample deck to the direct attack of a gas flame. For this purpose a cylindrical furnace, about 4 ft. long, is used. It consists of a combustion chamber about 6 in. in diameter, having a narrow slotted orifice on the top 36 in. long and ½ in. wide, and is provided with a shield which overlaps the sample, and makes up to the guide directing the air currents. Gas is supplied to the furnace through a perforated pipe, extending the full length of the combustion chamber. This is done in order to distribute the flow of gas evenly throughout the chamber.

The furnace is set at the lower edge of the sample to be tested, the shield overlapping the lower edge of the sample about 10 in. In operation the flame emerges from the combustion chamber through the slotted orifice in the top, and is carried to the sample by the air currents, sweeping over an area of approximately 6 sq. ft., and being in direct contact with the surface of the sample. Figs. 3 and 4 show the furnace in position and also in operation. During the test the sample is exposed to the air currents in the same manner as in radiation and hot brand tests.

Fig. 3. Furnace for Testing Roof Coverings.
Flame exposure furnace in position on sample deck.

In order to insure uniformity in the results a standard roof deck upon which to apply the roof coverings was adopted. The deck decided upon is 7 ft. wide and 8 ft. long and constructed of 7/8 in. by 8 in. undressed white pine boards, kiln dried, the boards being free from large or loose knots, sap or dry rot. They are laid across the shorter dimensions of the deck, spaced 1/4 in. apart, and nailed to 4 battens placed on the under side of the deck. The roof coverings are applied to the decks in accordance with the specifications advocated for their application in the field.

For the purpose of supplying the air currents a propeller fan eight feet in diameter was adopted. The fan is driven by a forty-horsepower motor and the speed controlled by means of a water rheostat.

The fan is set in the partition in the end of the test room, and takes its supply directly from outside of the building. The furnaces are placed in front of the fan, and the air discharged is directed by guides to the sample under the furnace. (See Fig. 1.)

The air currents are controlled by regulating the speed of the fan, and their velocities are measured by means of a Pitot tube.

In order to conduct the tests a special building 36 by 25 ft. was erected in yard at the laboratories. The building is constructed of studding, sheathed on the outside with sheet metal and on the inside with plaster boards, and is divided into 3 rooms. In the largest the fire tests are conducted and furnaces mounted. Adjoining at the end is a small room in which radiator coils to regulate the temperature of the air currents are placed. The fan is built into the partition separating these rooms. The third room extends the full length of the building and contains the motor and water rheostat for operating the fan, and provides for the storage of samples. The exterior of this building is shown in Fig. 5.

FIG. 4. FURNACE FOR TESTING ROOF COVERINGS.
Flame exposure furnace in operation. Exposing sample inclined at an angle of 45 degrees.

With the apparatus installed, a number of tests were first conducted in order to calibrate the furnaces and to ascertain the effect of air currents of various velocities upon their operation.

A second series of tests was then undertaken upon several representative types of roof coverings. These tests have progressed sufficiently to indicate that the apparatus adopted and methods employed are unsatisfactory, and the data obtained from this series formed the basis of the tentative specifications for the classification of roof coverings submitted in the annual report of the Committee on Devices and Materials.

FIG. 5. ONE OF THE TEST BUILDINGS AT UNDERWRITERS' LABORATORIES.

DISCUSSION.

(In the absence of the Chairman, the report was presented by Mr. Maurice Coburn, Principal Assistant Engineer, Vandalia Railroad, Vice-Chairman.)

Mr. Coburn:—Practically all the work done this year was confined to the matter of roofing. In the study of the roofings, the work divides itself naturally into two parts, the bituminous materials and the others. Of the other materials, there is nothing of special importance to the Association, except possibly the fact that we have called attention to the use of a purer iron in place of the impure irons, which have been used in the past with such poor results. In the case of the bituminous materials, we have found a very interesting subject. The bituminous material industry is in a primary state, as yet, and most of the accurate technical knowledge is in the possession of the manufacturers, and the securing of accurate information as to the relative qualities of the different materials has been a difficult matter. We think that our friends who are interested in water-proofing, and in the oils for creosoting timber and in road binders can testify as to similar experiences. We have endeavored to discuss the points regarding the materials which have been brought to our attention by the salesmen of the houses manufacturing the different materials, to enable the engineer to better understand their value as they are presented to us. We have suffered a good deal from the salesmen, but we hope to add a little general information so that this suffering can be mitigated in the future to some extent. We present a few conclusions, which we feel are conservative. We have left out reference to some important materials, about which our knowledge was not sufficient to allow us to form any conclusions.

The President:—This Committee has made a most valuable investigation of roof coverings, and it is that part of the Committee's report which is to be considered. You will find the conclusions on page 27 of the Bulletin. The report is now before the convention for discussion. If there is no objection we will read the conclusions.

The Secretary:—"The annoyance and indirect expense occasioned by leaky and short-lived roofs are rarely compensated for by any possible saving in first cost.

"In selecting a roofing, these should be considered:

"(1) Chance of leaks due to character of construction.

"(2) Probable life, including chance of damage by the elements and by wear from other causes.

"(3) Fire-resisting value.

"(4) Cost of maintenance.

"(5) Cost of materials.

"(6) Cost of laying.

"The ordinary practice of depending merely upon guarantees in selecting roofings cannot be trusted to secure proper results.

"Where proper materials and the requisite skill in application are available, built-up roofs of coal-tar felt, coal-tar pitch and gravel or slag are recommended for roofs with a pitch of two inches or less to the foot.

"Where the roof is to be subjected to wear and where the character of the construction warrants the expense, flat tiles or brick should be used as a protective coating to the roofing instead of gravel or slag.

"As a general proposition railroad buildings should be designed to accommodate this type to allow it to be used, and because of economy in construction and of decreased fire hazard. A pitch of from one-half to one inch to the foot is better than anything steeper. Nothing but straight-run pitch should be used.

"No contracts should be made for a built-up roof without a complete and positive specification including flashings, and the contract prices should not be less than those of the materials specified, plus a reasonable amount to cover the cost of laying and profit. Thorough inspection of workmanship and material is recommended.

"For slopes of from two to six inches to the foot fair results can be expected if the top coating of pitch be especially prepared. This can be successfully done only by skilled workmen, who are also necessary for its application. Especial care must also be taken in the selection and application of the stone or slag coating.

"Asphaltic compounds have value for a built-up roof for the top coating on slopes of from two to six inches to the foot. They may also be desirable at points where good coal-tar cannot be obtained, except at a cost appreciably greater. They should not be used except where they can be obtained from reputable dealers with complete information as to their constituents and where they can be applied by men skilled in their use.

"Ready or prepared roofings are recommended for use on small, temporary and other buildings where the cost, considering maintenance, of more expensive buildings, is not justified. They are of value for steep slopes where a built-up coal-tar roof cannot be used, and for locations where the skilled labor necessary for a built-up roof is not available. The steeper the slope the greater their relative value and the wider their economical field. The heavier varieties are, in general, the more desirable because of their chance for longer life and their greater fire-resisting value. In making selections the reliability of the manufacturer, service tests and the cost should be governing factors.

"In the laying of built-up and prepared roofings thoroughness in the preparation of flashings and work around openings is of vital importance.

"Slate and tile of suitable quality, properly protected and fastened, can be recommended on roofs with a pitch of six inches to the foot or over, where expense is not the governing feature, and where they aid in producing the desired architectural effect, except that where there is much chance of driving snow, eight inches to the foot should be the flattest slope allowed.

"Wood shingles, except in isolated locations where there is small danger from sparks, should not be used.

"Steel or impure iron materials should be avoided, no matter how protected."

Mr. Chas. S. Churchill (Norfolk & Western) :—I move the adoption of those conclusions. I think they are in excellent form.

Mr. C. E. Lindsay (New York Central & Hudson River) :—I second the motion, and referring particularly to recommendation 6, which occupies, as I understand, the bottom of page 127, and all of 128, the Committee has recommended the built-up roof of coal-tar for roofs with a pitch of two inches or less, and have permitted the use of asphalt only for an outer covering, on roofs with a pitch of more than two inches. Is this Association prepared to limit itself to the use of coal-tar exclusively for roofing? It seems to me that we ought not to go on record as recommending the exclusive use of the coal-tar pitch roof.

Mr. Coburn :—We say that asphalt compounds are valuable on the steep slopes. They may also be desirable at points where good coal-tar cannot be obtained except at a cost appreciably greater. We do not say they are not good on flat slopes. We do say coal-tar is better under ordinary conditions.

(The motion to adopt the conclusions carried.)

Mr. Coburn :—The Committee feels that we have a very difficult subject; that we have not by any means completed it. There has been very little chance for discussion this morning. We would appreciate active interest in the Committee's work and written suggestions or criticisms of the Committee's report in detail, or suggestions as to anything that has been left out.

The President :—The Committee will be excused with the thanks of the Association.

INDEX.

INDEX.

PART I.

A

Abrasion of Cross-Ties by Track Rails, 395-397.
Ames, Azel, discussion:
  On Rules and Organization, 92.
  On Signals and Interlocking, 131.
Anthony, C. C., discussion on Electricity, 223, 224, 229.
Austin, Jr., J. B., discussion on Electricity, 230.

B

Bagg, F. A., discussion on Wooden Bridges and Trestles, 310, 311.
Baldwin, A. S., re-election of, as Director, 25.
  Discussion on Masonry, 582, 583, 584.
Baldwin, Hadley, discussion on Electricity, 225.
Ballast, report on, 339-346.
  Conclusion, 343.
  Depth of Ballast Used by Various Railways, 345, 346.
  Discussion, 347-355.
  Proper Thickness of Ballast, 341-343.
Barrett, W. C., discussion on Track, 457.
Begien, R. N., discussion:
  On Ballast, 351, 354.
  On Economics of Railway Location, 336, 337.
  On Rail, 473.
Bergen, W. J., discussion:
  On Ballast, 351, 352.
  On Wooden Bridges and Trestles, 314.
Bibliography:
  On Electricity, 140-151.
  On Waterproofing Masonry, 564-578.
  On Yards and Terminals, 261, 262.
Bremner, George H., election of, as Treasurer, 25.
Brine Drippings from Refrigerator Cars, report on, 230-232.
  Conclusions, 232.
  Discussion, 233, 234.
Brooke, G. D., discussion:
  On Ballast, 353.
  On Manual, 28.
  On Track, 459.
  On Wooden Bridges and Trestles, 320.

Buildings, report on, 587-622.
Discussion, 623-625.
Objects of Tests and Investigations at Underwriters' Laboratories, 613-616.
Roof Coverings, 588-612.
Tests on Roof Coverings, 617-622.
Burgess, G. H., discussion on Yards and Terminals, 272.
Bush, Lincoln, discussion on Wooden Bridges and Trestles, 322, 323.
Business Session, 11-38.
Byers, M. L., discussion:
On Ballast, 349, 350.
On Manual, 28, 29, 36.
On Track, 451.

C

Camp, W. M., discussion:
On Ballast, 349, 352, 353.
On Electricity, 224, 227.
On Manual, 30-32.
On Track, 451, 452, 453, 460.
Cartlidge, C. H., discussion on Wooden Bridges and Trestles, 319.
Churchill, Chas. S., discussion:
On Buildings, 625.
On Electricity, 225.
On Rail, 467, 468, 469, 470, 471, 473, 474, 475.
On Track, 453, 461.
Clearances, 152-155.
Clearances on American Railways, diagrams showing, 166-198.
Coburn, Maurice, discussion on Buildings, 623-625.
Composite Ties, 371-389.
Concrete Trestles, reinforced, 517-529.
Constitution, 43-51.
Revision of, 38.
Condron, T. L., discussion:
On Wooden Bridges and Trestles, 316.
On Yards and Terminals, 265, 267.
Cross-Ties, abrasion of, by track rails, 395-397.
Statistics of, 359-370.
Courtenay, W. H., discussion:
On Ballast, 349.
On Brine Drippings from Refrigerator Cars, 233, 234.
On Wooden Bridges and Trestles, 308, 309, 310, 311, 312, 313, 314, 316.
On Yards and Terminals, 270, 271, 272.
Cushing, W. C., discussion on Rail, 469.
Election of, as President, 25.
(See also under "Vice-President.")
Cypress as Tie Timber, use of, 390-394.

D

Deceased Members, 14.
Drainage, rules regarding, 85, 86.

E

Economics of Railway Location, report on, 327-335.
  Balanced Grades for Use of Assistant Engines, 330-335.
    Adjustment Due to Weight of Car, 331.
    Balanced Grade for 0.3 per cent., 332.
    Balanced Grades for Helper Engine Service, 333.
    Balanced Grades for Use of Assistant Engines, 334.
    Formula for Freight Train Resistance, 330.
    Resistance Varies Inversely as Weight of Car, 330.
    Table of Adjustments, 331.
    Wellington's Figures, 332.
  Discussion, 336-338.
Electricity, report on, 135-220.
  Bibliography, 140-151.
  Clearances, 151-155.
  Clearances on American Railways, diagrams showing, 166-198.
  Conclusions, 164, 165.
  Discussion, 221-230.
  Maintenance Organization, 155-163, 199.
  Relation to Track Structures, 164.
  Transmission Line Crossings, 155, 200-220.
Elliott, W. H., discussion:
  On Electricity, 228.
  On Rail, 472.
  On Signals and Interlocking, 132, 133, 134.
  On Track, 456, 457, 460, 461.
Ewing, C. H., discussion:
  On Electricity, 227.
  On Rules and Organization, 133.

F

Financial Statement, 18-20.
Finke, W. F. H., discussion on Ties, 398.
Freight, mechanical handling of, 236, 237, 243-249.
Freight Yards for Interchange Traffic, 241.
Fritch, E. H., re-election of, as Secretary, 25.
Fritch, L. C., resolution of thanks to, Address of, as President.
  (See also under "President.")
Frogs, Crossings and Switches, general instructions for ordering or contracting for, 403-409.

G

Gibbs, George, discussion on Electricity, 223, 224, 225, 228, 230.
Grades, balanced, for use of assistant engines, 330-335.

H

Himes, A. J., discussion on Wooden Bridges and Trestles, 314, 315, 318, 320.
Hotchkiss, L. J., discussion on Wooden Bridges and Trestles, 309, 310, 311, 319.
Humphrey, Richard L., discussion on Masonry, 579, 580.

J

Jacoby, H. S., discussion on Wooden Bridges and Trestles, 307, 308, 311, 312, 314, 317, 318, 320, 322.
Jenkins, J. B., discussion:
On Track, 448, 453, 462, 463, 464, 465.
On Wooden Bridges and Trestles, 315.
Johnston, A. W., discussion on Rules and Organization, 92.
Resolution by, 39.
Jonah, F. G., discussion on Ties, 400.

K

Katte, E. B., discussion on Electricity, 223, 224.
Kenly, R. G., discussion:
On Brine Drippings from Refrigerator Cars, 233.
On Electricity, 226, 229.
On Rail, 472.
On Track, 454, 455, 457.
On Wooden Bridges and Trestles, 316, 319.
Kittredge, George W., discussion:
On Ballast, 353.
On Economics of Railway Location, 337, 338.
On Electricity, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230.
On Manual, 27, 28, 36, 37.
On Rules and Organization, 93.
On Wooden Bridges and Trestles, 318.
On Yards and Terminals, 269, 270.
Knickerbocker, C. E., discussion on Track, 447, 448, 449, 450, 453, 454, 455, 456, 457, 458, 459.

L

Lewis, E. R., discussion on Yards and Terminals, 264.
Library, 17.

Lindsay, C. E., discussion:
On Ballast, 350, 351, 354.
On Buildings, 625.
On Electricity, 223, 226, 230.
On Masonry, 579.
On Rail, 467, 468, 469, 470, 471, 472.
On Rules and Organization, 92, 93, 94.
On Track, 447, 448, 449, 450, 451, 452, 453, 455, 459, 460.
Lloyd, H. A., discussion:
On Rules and Organization, 96.
On Wooden Bridges and Trestles, 308, 322.
Loweth, C. F., discussion:
On Manual, 30.
On Masonry, 582, 585.
On Track, 458, 459, 461.
On Wooden Bridges and Trestles, 313.
Election of, as Director, 25.

M

McDonald, Hunter, discussion:
On Ballast, 347, 348, 349, 353, 354.
On Manual, 26, 27, 28, 36.
On Masonry, 586.
On Rail, 468, 474, 475.
On Track, 453, 465.
On Wooden Bridges and Trestles, 308, 314, 319.
McNab, William, discussion:
On Electricity, 229.
On Rules and Organization, 91, 92, 93, 94.
On Wooden Bridges and Trestles, 317, 318.
On Yards and Terminals, 263, 264, 265, 269, 273.
Maintenance Organization, 155-163, 199.
Mann, B. H., discussion:
On Electricity, 230.
On Rules and Organization, 93.
On Signals and Interlocking, 131, 132, 133.
On Track, 456, 461.
On Yards and Terminals, 263, 264.
Manual, discussion on, 26-37.
General Rules for Publication of, 56.
Masonry, report on, 477-578.
Bibliography of Waterproofing, 564-578.
Discussion, 579-586.
Monolithic Construction, 514-517.

Masonry—Continued.
Protecting and Waterproofing Solid Floor Bridges, 530-541.
Methods Used, 540-545.
Results of Examinations, 535, 536.
General Information and Comments, 536-539.
Conclusions, 540, 541.
Reinforced Concrete Trestles, 517-529.
Specifications and Instructions for Waterproofing Metal and Masonry Structures, Pennsylvania Lines, Southwest System, 542, 543.
Waterproofing of Masonry, 408.
Meade, J. M., discussion:
On Ballast, 348, 349, 352, 353.
On Brine Drippings from Refrigerator Cars, 233.
On Economics of Railway Location, 337.
On Rules and Organization, 133.
Membership, report on, 16.
Merrell, G. W., discussion on Ballast, 352.
Mock, J. C., discussion:
On Brine Drippings from Refrigerator Cars, 233.
On Electricity, 223, 225, 227, 228, 229.
Monolithic Construction, 514-517.
Morse, C. A., discussion on Ballast, 348, 349, 350, 352, 353.
Mountain, G. A., discussion on Electricity, 225.

N

Newbegin, P. C., discussion on Rules and Organization, 92.
New Business, 26-38.

O

Officers, election of, 25, 26.
Osgood, Jos. O., discussion:
On Ballast, 352.
On Rules and Organization, 91, 92, 94, 95, 96.
On Wooden Bridges and Trestles, 313.
On Yards and Terminals, 264.
Overdriving Piles, 281-286.

P

Parrish, F. J., discussion on Track, 453.
Passenger Terminals, facilities and traffic at, 254, 255.
Patenall, F. P., discussion on Track, 455, 456, 458.
Patterson, F. M., discussion on Masonry, 583.
Petersen, W. H., discussion on Masonry, 579, 580, 581.
Pile Drivers, 286-298.
Pile-Driving, Principles of Practice, 279, 280.
Pile Record Form, 278.

Piles, mechanical protection of, against marine wood borers, 305, 306.
Porter, H. T., discussion:
 On Electricity, 228.
 On Track, 452, 453, 455, 460.
 On Wooden Bridges and Trestles, 315, 316, 318, 319.
President, address of, 12-15.
Publications, 17, 18.

R

Rail, report on (see Vol. 12, Part 2, pp. 3-559).
 Discussion, 467-475.
Ray, G. J., discussion on Ballast, 354.
Reports:
 On Ballast, 357-397.
 On Brine Drippings from Refrigerator Cars, 231, 232.
 On Buildings, 587-622.
 On Economics of Railway Location, 327-335.
 On Electricity, 135-220.
 On Masonry, 477-578.
 On Rules and Organization, 59-90.
 Of Secretary, 16-19.
 On Signals and Interlocking, 07-129.
 On Track, 401-446.
 Of Treasurer, 19, 20.
 On Wooden Bridges and Trestles, 275-306.
 On Yards and Terminals, 235-262.
Resolutions of Thanks:
 To Automatic Annunciator Company, 37.
 To Committee on Arrangements, 38.
 To Railway Age-Gazette, 37.
 To Railway and Engineering Review, 37.
 To Railway Appliances Association, 38.
 To Past-President L. C. Fritch, 39.
Robinson, A. F., discussion on Wooden Bridges and Trestles, 310, 315.
Roof Coverings, 538-612.
 Bituminous Roofing Materials, 589-592.
 Built-up Roofs, 596.
 Conclusions, 610-612.
 Concrete Roofings, 608, 609.
 Cost, 600.
 Felts, 595-596.
 Fire Protection, 610.
 Inspection, 597-599.
 Iron or Steel Roofings, 607, 608.
 Methods of Application, 609, 610.
 Miscellaneous Metals, 608.

Roof Coverings—Continued.
Prepared or Ready Roofings, 601-605.
Slate, 606.
Specifications, 597-601.
Tars, 592-595.
Tests on, 617-622.
Tile, 606, 607.
Wood Shingles, 605, 606.
Rose, L. S., discussion:
On Electricity, 227.
On Manual, 29.
On Track, 447, 448, 451, 452, 453, 458.
On Yards and Terminals, 263, 264.
Rules and Organization, report on, 59-90.
Conclusions, 60, 61.
Compilation of Rules of Railway Companies, with Suggestions for New Rules, 63-90.
Discussion, 91-96.

S

Schall, F. E., discussion on Wooden Bridges and Trestles, 323, 324.
Secretary, report of, 16-19.
Seddon, W. L., discussion on Masonry, 583, 584.
Sheet Piles, 298-302.
Sheet Piling, strength of, 303, 304.
Signals and Interlocking, report on, 97-129.
Discussion, 131-134.
Double-Braided, Weatherproof, Galvanized "B" Iron Line Wire, 117-119.
Double-Braided, Weatherproof, Hard-Drawn, Copper Clad Steel Line Wire, 120-122.
Double-Braided, Weatherproof, Hard-Drawn, Copper Line Wire, 115-116.
Revised Specifications for Mineral Matter Rubber Compound Insulated Signal Wire for Current of 660 Volts or Less, 101-104.
Specifications for Mineral Matter Rubber Compound Insulated Aerial Braided Cables for Current of 660 Volts or Less, 105-109.
Specifications for Mineral Matter Rubber Compound Insulated, Lead-Covered, Armored Submarine Cable for 660 or Lower Voltage Service, 110-114.
Specifications for Galvanized E. B. B. Iron Bond Wires, 123-125.
Stranded and Flexible Conductors, 125, 126.
Wire Inspection Report Blank, 127.
Smith, C. E., discussion on Masonry, 583, 585, 586.
Snow, J. P., discussion:
On Track, 449, 450.
On Wooden Bridges and Trestles, 307, 310, 314, 316.

Specifications:
For Double-Braided, Weatherproof, Hard-Drawn, Copper Line Wire, 115, 116.
For Double-Braided, Weatherproof, Galvanized "B" Iron Line Wire, 117-119.
For Double-Braided, Weatherproof, Hard-Drawn, Copper Clad Steel Line Wire, 120-122.
For Galvanized E. B. B. Iron Bond Wires, 123-125.
For Mineral Matter Rubber Compound Insulated Wire for Current of 660 Volts or Less, 101-104.
For Mineral Matter Rubber Compound Insulated Aerial Braided Cables for Current of 660 Volts or Less, 105-109.
For Mineral Matter Rubber Compound, Insulated, Lead-Covered, Armored Submarine Cables for 660 or Lower Voltage Service, 110-114.
Spencer, C. H., discussion:
On Manual, 32.
On Rules and Organization, 93.
On Yards and Terminals, 271, 272.
Spirals, 417-438.
Steffens, W. F., discussion:
On Masonry, 580, 581, 584, 585.
On Wooden Bridges and Trestles, 309, 310, 311, 318.
Stein, C. H., discussion on Ballast, 351.
Stevens, F. S., discussion:
On Manual; 33.
On Wooden Bridges and Treastles, 318.
On Yards and Terminals, 263, 265, 267, 268, 269, 270, 272.
Stimson, Earl, discussion on Ballast, 353.
Sullivan, J. G., discussion on Track, 452, 464.
Switches, general instructions for ordering or contracting for, 403-409.
Switch Points, manganese in, 410.

T

Talbot, A. N., discussion on Track, 447, 462, 463.
Temple, E. B., discussion:
On Wooden Bridges and Trestles, 315, 319.
On Yards and Terminals, 270, 271, 272.
Thompson, A. W., discussion:
On Economics of Railway Location, 338.
On Yards and Terminals, 267, 268.
Ties, report on, 357-397.
Abrasion of Cross-Ties by Track Rails, 395-397.
Discussion, 398-400.
Metal and Composite Ties, 371-389.
Statistics of Cross-Ties, 359-370.
Use of Cypress as Tie Timber, 390-394.
Tinker, G. H., discussion on Track, 449.

Track, report on, 401-446.
Conclusions, 415.
Discussion, 447-465.
General Instructions for Ordering or Contracting for Frogs, Crossings and Switches, 403-409.
Manganese in Frogs, Crossings and Switch Points, 410.
Spirals, 417-438.
Derivation of Formulas, 420-424.
Formulas for Field Use, 424, 425.
Fundamental Formulas, 420.
Maintenance of Line and Alinement, 427.
Minimum Length of Easement Curve, 428.
Notation, 418-420.
Staking Spirals by Deflections, 426.
Staking Spirals by Offsets, 427.
Table of Functions of the Ten-Chord Spiral, 429-438.
Track Fastenings with Treated Ties, 410-415.
Transition Spirals, selection of length of, 439-446.
Transmission Line Crossings, 155, 200-220.
Treasurer, report of, 19, 20.
Treated Ties, track fastenings with, 410, 415.
Trimble, Report, discussion on Manual, 29, 30, 32, 33.

W

Waterproofing Masonry, 480-514.
Waterproofing Solid Floor Bridges, 530-541.
Wendt, Edwin F., discussion:
On Ballast, 353, 354.
On Manual, 33-36.
On Masonry, 579, 580.
On Rail, 471, 472.
On Ties, 398-400.
On Track, 453, 458.
Election of, as Vice-President, 25.
Wentworth, C. C., discussion on Rules and Organization, 93.
Wickhorst, M. H., discussion on Rail, 470, 471, 472.
Williams, S. N., discussion:
On Ballast, 347, 348, 349, 350, 352, 353, 355.
On Rules and Organization, 94.
On Ties, 398.
On Yards and Terminals, 264, 272.
Wire Inspection Report Form, 127.
Wood, B. A., discussion on Wooden Bridges and Trestles, 324, 326.
Wooden Bridges and Trestles, report on, 275-306.
Conclusions, 276, 277.
Discussion, 307-326.

Wooden Bridges and Trestles—Continued.
- Mechanical Protection of Piles Against Marine Wood Borers, 305, 306.
- Overdriving, 286.
- Pile Drivers, 286-298.
- Pile Driving, principles of practice, 279, 280.
- Pile Record Form, 278.
- Sheet Piles, 298-302.
- Strength of Sheet Piling, 303, 304.

Yards and Terminals, report on, 235-262.
- Arrangements for Loading Tracks at Piers, 250-253.
- Bibliography on Stations, Yards and Terminals, 261, 262.
- Conclusions, 240.
- Design of Passenger Terminals of Medium Size, 237-240.
- Discussion, 263-273.
- Facilities and Traffic at Passenger Terminals, 254, 255.
- Freight Yards for Interchange Traffic, 241.
- Improvements for the Handling of Interchange Freight Business at Chicago, 256, 257.
- Mechanical Handling of Freight, 236, 237.
- Notes on New Passenger Terminals, 257-260.